FIRST LINES

OF

PHYSIOLOGY,

BY THE CELEBRATED
DEGO
BARON ~~ALBERTUS HALLER~~, M.D. &c.

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TO WHICH ARE ADDED,
The valuable INDEX originally compoſed for
Dr CULLEN's EDITION;

AND ALL THE
NOTES and ILLUSTRATIONS of PROF. WRISTBERG,
now firſt tranſlated into ENGLISH.

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FIRST LINES

OF

PHYSIOLOGY.

CHAP. XVII.

Of the SIGHT.

CCCCXCVIII. AS the organ of hearing perceives the tremors of the air, ſo the ſight perceives thoſe of light: and as the firſt conſiſted chiefly of bony organs capable of making a reſonance; here, on the contrary, the greater part of the eye is compoſed of pellucid humours capable of refracting the more ſubtle medium of light: but the complexity of this organ was neceſſary for the defence of its tender parts, and from the diverſity of the ſeveral humours to be contained each in their proper integuments.

CCCCXCIX. Outwardly, a defence is afforded to this organ by the eye-brow or *ſupercilium*, which is a protuberance of the ſkin ſuſtained by muſcles, at the bottom of the forehead, full of thick hairs, lying over one another like the tiles of a houſe; and capable of being pulled down by the action of the frontal, corrugator, and orbicular muſcles, ſo as to afford a ſhade to the eye in too ſtrong a light. After this office is finiſhed, the eye-brow is raiſed again, by the inſertion of the frontal muſcle, thin and fleſhy, immediately under the continuous ſkin, faſtened to the cellular membrane of the ſkull, which is of a ſhining ſubſtance, and not far different from the nature of an aponeuroſis, which, being, of a long quadrangular figure, is drawn backward by the occipital muſcle. A depreſſion of the eye-brow ſerves alſo to expreſs concern of the mind; as an elevation of it denotes the mind to be in a ſerene quiet ſtate. This guard alſo conduces to throw off the ſweat and retained duſt, or the inſects which might fall into the eye.

D. The *eye-lids*, or palpebræ, are placed ſtill nearer guards to the eye. Here the folds of the ſkin, which are thinly extended, from that of the face, run out in a conſiderable length, and are reflected back with the cellular ſubſtance interpoſed betwixt the outer and inner plate; the latter of which becomes then a thin vaſcular membrane, and therefore of a red colour, extended before the globe of the eye, and ſpread in its foremoſt part upon the ſclerotica, under the denomination of *conjunctiva tunica*. This production of the ſkin is every where covered by another of the cuticle, even where it is cloſely conjoined with the cornea. The upper eye-lid is larger and more moveable: the lower is ſmaller, and rather obſequious to the motion of the other parts, than moved by any particular forces of its own. The *nerves*, which give ſenſibility to the eye-lids, are numerous, from the firſt branch of the fifth pair, and likewiſe from the ſecond, and from the hard branch of the ſeventh pair; they abound with *arteries* from the ophthalmics, and from the branches of the temporals, internal maxillaries, infra-orbitals, and others of the face.

DI. That the eye-lids might ſhut together more exactly, they have each of them a cartilaginous arch, called *tarſus*, upon their margins, which meet together,

ther. It is ſlender, of a lunar figure, extenuated outward, and ſerves to hinder the eye-lid from falling into wrinkles while it is elevated or depreſſed. The elevation of the upper eye-lid is performed by a muſcle ariſing from the involucrum of the optic nerve gradually ſpreading, and extended by its expanſion to the tarſus. This elevator is conſiderably aſſiſted in its action by the frontalis, and by various connections with the orbicularis drawn up or dilated by the former. The upper eye-lid depreſſed by the *orbicularis* muſcle; which is broad and thinly ſpread round the orbit, under the ſkin of the eye-lids, to each angle of the eye, which ſerve as fixed points to this muſcle; and it adheres to the os frontis, where that bone joins the upper jaw, and then its fibres are inſerted into the os frontis and neareſt parts of the upper jaw. The ſame muſcle ſerves to elevate the lower eye-lid, and covers the eye in ſuch a manner that no duſt or light can enter it in ſleep. The lower eye-lid is depreſſed by a double portion of fibres, inſerted into the upper-lip.

DII. Finally, that the protuberant margins of the eye-lids might not injuriouſly beat againſt each other, the *cilia* or rails of hair are placed ſpreading outwards, in a row, from the edges of the eye-lids, of different lengths, which by croſſing each other make a blind or ſhade. Theſe are of uſe in more diſtinct viſion, by excluding the extraneous rays, when we require a diſtinct repreſentation of any object.

DIII. That the eye-lids rubbing againſt each other might not grow together, they are ſupplied with a row of *ſebaceous glandules*, firſt noticed by Meibomius; namely, about thirty little gut-like cells or more in each eye-lid; placed in general according to the length of the lid, without ever branching, but compoſed of peculiar blind ſinuſes, which end at laſt in one larger ſerpentine duct, opening by a mouth in the margin of the eye-lid itſelf. Theſe diſcharge a ſoft liniment, which mixes and waſhes off with the tears.

DIV. But the perpetual attrition of the eye-lids aſcending

ſcending and deſcending againſt the globe of the eye, is prevented by the diſtilling humour called *tears*; which preſerve alſo the tenderneſs of the membranes and of the cornea, and ſerve to waſh out any inſects or other ſharp corpuſcles. Theſe form a ſaline pellucid liquor that may be evaporated, and never ceaſes to be poured over the anterior ſurface of the eye; but never runs over the cheeks, unleſs collected together in a larger quantity from ſome cauſe. This liquor is exhaled partly from the arteries of the conjunctiva, as we ſee from an imitation of nature by injecting water: and it is in part believed to proceed from a gland ſeated in a receſs of the orbit of the os frontis, ſomewhat hard, and of the conglomerate kind; intermixed with fat, and painted with many blood-veſſels from the ophthalmics and internal maxillaries; and interſperſed with many ſmall nerves ariſing from a peculiar branch of the firſt trunk of the fifth pair.

DV. From this lachrymal glandule in horned cattle deſcend three, four, or more viſible ducts, which open on the inner ſide of the conjunctiva, upon the eye-lid. In man thoſe ducts are lately found out, according to credible authors [134]. The ſeparation of the tears is increaſed by the more frequent contraction of the orbicular muſcle, either from irritation, or ſome ſorrowful paſſion, by which means the tears are urged over the whole ſurface of the eye and conjunctiva, which they waſh.

DVI. After the tears have performed their office, ſome part of them flying off into the air, the reſt, that they might not offend by their quantity, are propelled by the orbicular muſcle towards its origination next the noſe, to a part which is the loweſt of the palpebral margins; which not being ſurrounded by the tarſus, does therefore not meet exactly together. Here a *caruncle* full of ſebaceous hairy follicles, of an oblong figure, interpoſes and ſeparates the meeting of the eye-lids, at the ſame time furniſhing a liniment to thoſe parts which have none of the Meibomian ducts. Before this part is extended a ſmall portion, like a little eye-lid; which, deſcending perpendicularly, joins the true eye-lids, and is larger in beaſts than in men: but at the beginning of this ſpace, betwixt the eye-lids, in which the tears are collected, both in the upper and lower margin, a little papilla ſtands out, having each of them one opening, ſurrounded by callous fleſh, which are perpetually open, unleſs when convulſively cloſed. This opening, which is called the *punctum lachrymale*, drinks up the tears from the ſinus in which they are collected; and this partly by tubular attraction, and partly by impulſe from the orbicular muſcle. If theſe points or openings are obſtructed, the tears run over and excoriate the cheek.

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[134] If I followed the method of the celebrated Monro and Hunter, I could with a ſmall ſyphon make canals viſible in three places, coming from the inner ſide of the palpebræ into the gland.

DVII. From both points proceeds a ſmall duct, both from the upper and the lower eye-lid, much wider than the opening itſelf, but thin, and included in the ſkin; one of which goes downward above the caruncle, and the other goes more tranſverſely inward and under it: theſe both join together, and are inſerted by two mouths near the uppermoſt part of the *lachrymal ſac*: thus it is called a cavity, formed in the os unguis and upper jaw, lined with a membrane, which is at firſt cellular, but harder, and as it were of the nature of an aponeuroſis; then by another red and pulpy one, continued from the membrane of the nares, pervious to the exhaling dew, and ſomewhat of an oval figure. From the ſame ſacculus is continued a duct, which deſcends a little backward into the nares, opening there by an oblique oblong aperture at the bottom of the meatus, covered by the lower os ſpongioſum. Through this paſſage the ſuperfluous tears deſcend into the noſe, which they in part moiſten (CCCCLXIV.) A muſcle is by ſome aſcribed tò this ſac; but it is not yet ſufficiently confirmed[135].

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[135] The famous Janin has lately propoſed an ingenious conjecture concerning the road of the tears, comparing the lachrymal ſac to the bladder

DVIII. The globe of the *eye*, compreſſed before, but longer than it is broad, is ſeated in the cavity of a bony orbit, which is almoſt of a conical figure, made up by ſeven bones which are in the back part; and on the inner-ſide perforated or interrupted by larger fiſſures, from whence the bones, widening forward, defend the cavity on all ſides. But as this is larger than the eye itſelf, the exceſs is on all ſides occupied by a very ſoft fat, ſurrounding the globe of the eye, that it may both fill and have a free motion within the orbit.

DIX. The eye begins from a conſiderable nerve, by the expanſion of whoſe coats thoſe of the eye itſelf are compoſed[136]. The origin of this optical nerve we have already deſcribed (CCCLVII.) Its progreſs is acroſs the crus of the brain, where it joins with its fellow nerve from the other ſide, and coheres therewith for a conſiderable length by a large portion of medullary ſubſtance; ſo that the right goes to the right eye, and the left to the left eye, yet not without ſome conjunction of both medullary ſubſtances. The nerve, therefore, thus enters the orbit a little inflected, of a figure ſomewhat round, but compreſſed; and is inſerted into the globe of the eye, not in the middle, but a little nearer to the noſe.

DX. The nerve having reached the eye, depoſites the inner plate of its dura mater, which it received in the opening of the ſphenoidal bone: and this being expanded and rendered thicker, makes up the firſt coat of the eye, called *ſclerotica*. The other outer plate of the dura

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bladder of urine, which retains the urine for any time, till it is thrown out, the ſphinctre being relaxed. He therefore aſcribes a ſimilar ſphinctre to the naſal canal, which is ſometimes ſhut, and again relaxed, that the tears collected in the ſack may run out through the noſtrils. The phenomena of the excretion of the tears, the tighter conſtriction which ſometimes ſhuts up the canal, and its folded ſtructure, render this opinion probable enough, although diſſection has not yet ſhown me any muſcular fibres.

[136] A more accurate anatomy now explodes this ancient error; for none of the tunics of the eye, the retina excepted, into which the optic is evidently changed, ariſes from the tunics ſurrounding the medulla of the nerve.

dura mater, receding from the former, makes up the perioſteum of the orbit: but the pia mater, which is in this nerve very diſtinct and full of veſſels, expands itſelf as before, ſo as to form a thin dark-coloured lining to the ſclerotica. The remaining inner medullary part of the nerve, continued from the brain, but divided into filaments by the cellular ſubſtance, is contracted into a depreſſed white conical papilla; after which it is again expanded upon the inner membrane of the eye, ſo as to form the *retina*.

DXI. The *ſcelerotica* is in general white, tough, and furniſhed with few veſſels, reſembling the nature of the cutis or ſkin, of a figure completely enough globular, but compreſſed or flattened before, and of a greater thickneſs backward. To the fore-part of this globe, cut off circularly, is prefixed obliquely a portion of a more convex but leſs ſphere; pellucid[137], and made up of many ſcales or plates, repleniſhed with a clear water, and pellucid veſſels very difficult to demonſtrate; inſenſible, and almoſt circular, yet broader at the noſe than towards the temples: it is termed the *cornea*, thro' which the light paſſes into the inmoſt part of the eye. This greedily imbibes water, and ſweats it out again. Before the anterior and flatter part of the ſclerotica, and alſo before the cornea, the conjunctiva is detached from each of the eye-lids, and cloſely conjoined to the ſclerotica by a proper cellular ſubſtance, that may be inflated (D.); which is repleniſhed with veſſels, partly red, and partly pellucid continuations of red ones.

DXII. The origination of the *choroides* is from the circumference of a white circle, terminating the ſubſtance of the optic nerve, in that part where the retina and the central artery are expanded from it, and perforate it by many ſmall foramina. From hence it ſpreads within the ſclerotica, concentrically adhering thereto by a cellular ſubſtance and many veſſels, which enter from the choroides into the ſclerotica. This membrane

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[137] That limpid water exſudes through the moſt ſubtile pores, and contributes ſomewhat to increaſe the quantity of the tears.

is outwardly of a brown colour, but inwardly of a more ruſſet brown or almoſt black, both which colour and ſurface are ſeparable by maceration: the innermoſt may be diſtinguiſhed by the name of *Ruyſch;* but grows white through age. When this has extended itſelf as far as the beginning of the pellucid cornea, it there joins itſelf more accurately to the ſclerotica by a cellular ſubſtance; from whence going off almoſt circularly in a different courſe, it forms a kind of rim, called *orbiculus ciliaris:* namely, the coat, which was before ſpherically expanded, now ſubtends circularly from the arch of the cornea, a little convex outwardly, and with a deficiency in its middle; from whence a circular parallel portion is taken out, ſo as to form a foramen or hole, called the *pupil*, which is ſeated nearer toward the noſe, and is larger toward the temple. The anterior part of this round rim, is called the *iris;* and the back-part, ſeparable from the former by maceration, is, from the black colour with which it is painted, called *uvea.* On the anterior ſurface of the iris appear numerous ſtripes, extended like rays, of various colours in different people, the whole covered as it were with little locks of wool. Theſe go off beyond the pupil into a ſerrated circle, from which tend other ſimilar ſtreaks, even to the edge of the iris. They are ſerpentine in a broad pupil, but ſtraight in a narrow one. On the poſterior face of the uvea is much black pigment; which being waſhed off, ſtraight radiated ſtreaks appear, produced into the pupil, but not woolly. Orbicular fibres, concentrical with the pupil, I have not been able to obſerve, neither with the naked eye, nor with a microſcope, even in an ox; but only in the uvea, an internal circle diſtinguiſhed by obſcurer rays, but leſs woolly. In the human fœtus, the pupil and the iris being produced, makes a complete circle [138].

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[138] This is the famous membrana pupillaris, ſufficiently deſcribed by Albinus, Wachendorff, Hunter, Haller, Walker, and myſelf. In the ninth month of pregnancy it generally diſappears, rarely remaining after birth, though I once ſaw it. While it is preſent, the cameræ of the eye are really ſeparated.

That part of it which is drawn over the pupil is of a vaſcular texture. About the time of birth, it gradually retracts, diſappears, and allows a free paſſage to the rays of light.

DXIII. Though the iris has little ſenſation, and is not endowed with any mechanical irritability; yet in a living man, quadruped, or bird, it is conſtricted on every greater degree of light, and is dilated on every ſmaller one; hence it is rendered broader for viewing diſtant objects, and narrower for viewing ſuch as are near. The cauſe of this dilatation ſeems to be a remiſſion of the powers reſiſting the aqueous humour; an argument of which, is the dilatation of the pupil, occaſioned by debility, and which ſucceeds ſyncope and death. The contraction is more obſcure, and perhaps only depends on the ſtronger afflux of humours into the colourleſs veſſels of the iris, into which theſe veſſels are extended [139]; and, along with theſe, the iris is rendered longer, and ſhuts the greater part of the pupil: ſo that this motion has ſomething in common with a beginning inflammation. The pupil is more evidently moved and contracted; as the eye gradually grows callous in old people, it is rendered almoſt immoveable. In an animal twenty or thirty hours dead, I have ſeen the iris extend by heat, and ſhut the pupil.

DXIV. Behind the uvea, from the ſame circle by which the choroides and ſclerotica join together, and outwardly adhere to the cornea, ariſe thick ſtripes, extended from the choroides, elegantly wrinkled with parallel

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[139] And my own experiments alſo have convinced me, that the iris does not belong to the parts endowed with regular irritability; for the ſolar light, or that of any other lucid body, if it ought to exert its effects upon the iris, that part of it taken in through the narrow channel ought to be conveyed to the retina; whereas, directed upon any other place of the iris, it remains without any ſuch effect. Theſe phenomena of the motion of the iris alſo convince me ſo much the more; beſides anatomical proofs, by which it is undoubtedly certain, that it has no real muſcular fibres, and that the contraction and dilatation of the pupil is rather to be aſcribed to the veſſels than to muſcles, although Janin endeavours to prove the preſence of muſcles by chirurgical reaſoning.

rallel veſſels, ſpread under them, which are conjoined by feather-like looſe and thin foot-ſtalks, into the retina, every way ſpread with a good deal of black paint; and departing, after the manner of a perforated ring, inward from the tunica choroidea, they ſpread upon the vitreous humour; and, laſtly, are laid on the capſule of the cryſtalline lens, but do not adhere to it, and are called by the name of the *ciliary ligaments*. The origin of the black pigment we are as yet unacquainted with; nor can any glandules be found, which ſome have aſſigned for its ſeparation. Among its other uſes, one ſeems to be to keep firm the cryſtalline lens. In infants, this ſame mucus has the image of a radiated flower behind the ciliary proceſs.

DXV. But the *retina*, which is truly a continuation of the medulla from the optic nerve, is next expanded into a ſphere concentric with the choroides, extremely tender, and almoſt of a mucous conſiſtence, diſſolvable by a blaſt; and this immediately embraces the vitreous body. But when the retina has extended itſelf as far as the ciliary proceſſes, it follows their courſe, making their ſtripes and ſmall arteries its foundation or ſupport in its courſe to the cryſtalline lens, to the capſule of which it adheres; and if we may believe the obſervations of ſome anatomiſts, as well as our own, ſpreads upon its ſurface [140].

DXVI. Theſe coats of the eye, which inveſt and ſupport each other, after the manner of an onion or other bulbous root, give a ſpherical figure to the eye, and include its *humours*: by which name are underſtood commonly three ſubſtances; the one a ſolid, the other a ſoft body, and the third truly a liquor. Firſt, then, the common ſurface of the retina is, on all ſides, filled by the principal or *vitreous* humour, which is contained in a thin pellucid membrane of its own, of a cellular fabric, in the intervals of which is confined a moſt clear liquor, a little denſer than water, which entirely evaporates by heat, like the aqueous humour: from which nature it does not eaſily degenerate, even in old people. Its veſſels, which are moſt manifeſt in fiſh, lie in the back part; are moſt beautifully radiated from the central trunk of the retina, embracing the convexity of the vitreous humour; and are inſerted into a circle formed by other arteries coming from the choroides, not far from the lens, and which I have ſeen in a ſheep. The vitreous membrane, which is tender conſidering its body, is yet grown to the lens in two places, before and behind; ſo that the middle hollow ring is intercepted between both inſertions, round the cryſtalline lens. Afterwards it is divided by ſome little ropes. The ſtreaks of the ciliary body imprint their marks on the anterior face of it.

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[140] Among all my obſervations upon the eye of man or of brutes, I find none to favour the opinion that the retina is ſpread over the capſule of the lens. I have ſeen the end of that medullary membrane every where circumſcribed behind the greateſt circle of the lens.

DXVII. But, in the fore-part of the vitreous body, behind the uvea, there is an orbicular depreſſion or ſinus conſiderably deep, into the cavity of which the *cryſtalline lens* is received, though that be leſs properly ranked in the claſs of humours. The figure of this lens is made of two elliptical convex portions or ſides, the foremoſt of which is flatter, and the poſterior more gibbous. The ſtructure of it is that of concentric plates or ſcales, ſucceeding each other, and compoſed by the fibres themſelves, elegantly figured and contorted, and connected by cellular fibres, ſo as to form a tender cellular texture. Betwixt the cryſtalline leaves is alſo contained a pellucid liquor, which in old age turns of its own accord to a yellow colour. The innermoſt ſcales lie cloſer together; and form at laſt a ſort of continued nucleus, harder than the reſt of the lens: it does not ſo adhere to the capſule, but, when that is broke, it very readily leaps out; and ſome ſay that a little water is effuſed around it. Its artery is from the retina, which perforates the middle of the vitreous humour; that is, the poſterior one; for the veſſels in the fore-part are not yet known. This whole lens is contained in a ſtrong, thick, elaſtic capſule of a pellucid membrane, more firm in the fore-part, which is lined backward by the vitreous tunic.

DXVIII. Laſtly, the *aqueous humour*, which is extremely clear and fluid, and renewed again if it be let out [141], is ſeated in a ſmall ſpace of a curve-lined triangular figure betwixt the uvea and cryſtalline lens, and in a larger chamber that is before betwixt the iris and the cornea. This humour ſeems to exhale from the ſmall arteries of the iris, uvea, and ciliary proceſſes; being again abſorbed into ſmall veins of the ſame parts, while ſome portion of it is drunk up and exhaled thro' the cornea. This humour alſo waters the uvea and capſule of the lens. About the beginning of the preſent century, the ſpaces filled with this liquor were called the *cameræ* of the eye; the fore one between the cornea and iris; the poſterior one, which is ſmall, between the circumference of the cryſtalline lens and the uvea.

DXIX. The eye, thus framed, is outwardly ſurrounded with muſcles for its government and direction. Namely, into the circle of the ſclerotica, which is next to the cornea, are inſerted four ſtraight muſcles, ariſing from the dura mater of the optic nerve at the bottom of the orbit; where, departing from the nerve, they cohere with the perioſteum, forming, as it were, one circle; from whence, going forward, their bellies lie round the bulb of the eye, and terminate again by their aponeuroſes, meeting together in another circle into the ſclerotica. Of theſe, the elevator is the leaſt, and the abductor the longeſt. The office of theſe muſcles appears very plainly in each of them apart; ſince, being bent round the convex bulb of the eye, as about a pulley, they muſt, of courſe, elevate, depreſs, or turn the globe of the eye either to the noſe or to the temple. Moreover, two of them acting together may turn the eye in a diagonal betwixt the former directions; as upwards and outwards, upwards and inwards, &c. Laſtly, when all the four ſtraight muſcles are contracted, there is no doubt but they draw the whole eye towards its origin within the orbit, by which means the cryſtalline lens is moved nearer to the retina.

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[141] It is undoubtedly included in a very tender membrane, which cannot be made viſible and preſerved without the moſt concentrated lixivial fluid.

DXX. But the two *oblique muſcles* of the eye are of a more compound fabric. The upper of theſe, ariſing together with the recti, is long and ſlender, aſcending forward to a notch in the os frontis, which is completed by a double ligament, cartilaginous on each ſide, and hollow in the middle, almoſt quadrangular, for ſuſtaining the tendon of the muſcle. Through this canal paſſes the tendon of the obliquus ſuperior; which being again reflected backward and downward, included in a capſule of its own, is inſerted into the globe of the eye behind the ſtraight muſcles. This draws the globe forward and upward, in a manner out of the orbit, that the eye may take in a larger field of viſion; it alſo turns the pupil inward and downward. The other *leſſer oblique* muſcle, ariſing from a ſinus of the lachrymal foramen in the upper jaw, aſcends immediately outwards from the os unguis round the globe of the eye, and is inſerted by its tendon into the ſclerotica behind the external rectus: whence it appears, on its part, to turn the eye downward and outward; and of courſe, contrary to the former, to direct the pupil upward and inward.

DXXI. But there are other more minute muſcular motions performed in the eye, which preſuppoſe a knowledge of the nerves belonging to this organ [142]. And, firſt, we have already ſpoken of the optic nerve (DIX, DX). The fourth pair goes only to the larger oblique muſcle, and the ſixth pair belongs to the ex-

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[142] It is an ancient obſervation, that the eye, with its muſcles, in proportion to their ſize, is ſupplied with an incredible number of nerves, making uſe of the whole ſecond, third, fourth, and ſixth pairs, except a root to the intercoſtal, and a great part of the firſt branch of the fifth. Janin has told us, that the eye has nerves from the pathetic and ophthalmic alone.

ternal rectus. The third and fifth pair produce the principal nerves in the eye; and of theſe, the firſt branch of the fifth produces the opthalmic nerve, and ſends off a ſmall nerve from its entrance into the orbit, to the eye-lid and lachrymal glandule; it then conjoins with the ſecond branch of the fifth pair, and with the temporal branch of the third and fifth pair. After having entered into the orbit, its trunk divides into two. The upper and larger ſubdivides into two, which are ſpent upon the forehead and eye-lids: but the lower, going inwards above the optic nerve, ſends out long ſlender filaments to the outer part of that nerve, which, joining with another filament of the third pair, makes up the ophthalmic ganglion, and ſends off one or two ciliary nerves. Finally, having given off a nerve, running to that of the noſe (CCCCLVII.), it is then ſpent upon the different parts of the internal angle of the eye.

DXXII. But the principal dignity of the *third pair* lies in giving off a branch upwards to the ſtraight muſcles of the eye, and to the eye-lids; and then, going forward with its trunk under the optic nerve, it ſends out three branches together to the lower and leſs oblique, and to the internal muſcle; after this, or often before, (from its trunk, and ſometimes from a branch of the lower obliquus), aſcends out another ſhort and much thicker nerve, which ſometimes joins the root of the fifth (DXXI.), or is ſometimes ſolitary; which, under the abductor muſcle, conſtantly forms the oval ophthalmic ganglion. From that ganglion, and ſometimes from the trunk of the third or fifth, go out four or five ciliary nerves in a crooked courſe, playing round the optic nerve in their courſe to the globe of the eye, where they enter the ſclerotica almoſt in its middle, in company with its longer ſmall arteries or veins; and running thence ſtraight forward through the choroides, they paſs viſibly to the iris, and ſeemingly to the ciliary proceſſes. Other very ſmall nerves, originating from the ſame ganglion, remain in the tunica ſclerotica.

DXXIII. Another more obſcure and leſs eaſily demonſtrable motion in the eye, is that of the ciliary proceſſes (DXIV.); which, lying incumbent upon the furrows of the vitreous membrane, ſeem, by their action, to preſs back that body, ſo as to bring the lens forward, and ſeparate or remove it farther from the retina. But I have never ſeen, in all the animals I have diſſected, any thing like a muſcle in this ciliary body; but a membrane which ſupports the ſmall veſſels. As for any ſphincter of the pupil, or a conſtrictor of the cornea, mentioned by ſome writers of note, or even moving fibres, which others have imagined proper to the cryſtalline lens, they are in nowiſe ſupported by anatomy, nor are they conſiſtent with the perpetual hardneſs of texture obſervable in the lens and cornea of moſt animals.

DXXIV. Moreover, to the hiſtory of the eye belongs a deſcription of the veſſels, which in this part have a beautiful fabric. But all of thoſe which belong properly to the ſeveral parts of the eye itſelf come from the ophthalmic artery, a branch of the internal carotid (CCCXVI.). This, creeping along under the optic nerve, ſends out, as principal branches, the upper and lower ciliaries, one or more; the lachrymalis, fromwhence the poſterior running to the noſe, and internal part of that belonging to the arch of the tarſus; afterwards the muſcularis inferior, the anterior recurrent to the noſe, the uppermoſt muſcularis, and the palpebralis; from whence, with the former branch, ſprings the arch of the tarſus. Laſtly, it goes out forward to the face and adjacent parts of the noſe. But the opthalmic branches, belonging to the inner fabric of the eye, are the poſterior and middle ciliaries; which, ariſing from the trunks before mentioned, and playing round the optic nerve, in four or more branches, in a ſerpentine courſe, go partly in with the optic nerve at its firſt entrance, and are partly extended further to near the middle of the ſclerotica [143], where they ſend in forty or more little arteries to the choroides, which make firſt beautiful ramifications upon the external ſurface of that membrane, round, and like the branches of trees; from whence they proceed inwardly in a more direct courſe, and at laſt go to the *circle* of the uvea.

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[143] Neither in man in general, nor even in the larger brutes, do the

DXXV. But ſeveral of the ſmall arteries of the tunica choroides gradually decline towards the interior parts of the eye; and, being covered with a kind of cellular woolly matter, go to the ciliary proceſſes, through each of which run out two ſmall arteries, ſcattering vaſcular woolly-like locks, united by an handle at their apex.

DXXVI. Other ſmall arteries alſo, likewiſe ariſing from the ciliary ones, but few in number, moſt commonly two, come to the ſame baſis from which the membrane of the uvea originates. There, ſpreading in various directions, they ſurround the root of the uvea with their branches, and are joined into a circle, into which the anterior ciliares mix themſelves; which are ſmall arteries ariſing from the muſcular branches of the ophthalmic, near the origin of the pellucid cornea; perforate the ſclerotica by twelve or more branches, and together make up the circle of the pupil. From that circle, and likewiſe from the fore-mentioned anterior ciliary arteries, independent of the middle circle, are diſtributed veſſels, both on the anterior face, which makes the iris, and on the poſterior face of the uvea, together with the ciliary proceſſes; the veſſels are diſtributed, both ſtraight and ramified; the iris is full of a liquor of a bluiſh colour, otherwiſe brown; and the uvea is ſpread with a good deal of a black paint, without which it is naturally white. In the uvea, at ſome diſtance from the pupil, they frequently form an imperfect circle.

DXXVII.

the ciliary arteries ſimply perforate the ſclerotica; but any whole trunk of the ciliary artery enters the foramen on the outer ſide of the ſclerotica, and in the very ſubſtance of the ſclerotica it ends between the plates of this tunic in a plexus of thin threads, from which five or ſix leſs branches iſſue; and coming through as many holes out of the inner ſurface of the ſclerotica are diſtributed through the choroid.

DXXVII. But from the ſame opthalmic and its trunk, or from the lachrymal branch, or from one of the ciliaries, one or more branches enter into the optic nerve; the principal central artery of the retina penetrates thro' the medulla of the nerve, and, going out of the apex of the papilla (DX.), divides in the centre of the retina; from thence ſpreading every way in company with the retina itſelf[144], by ſo many branches, when traced by a ſkilful anatomiſt, that that vaſcular net-work is taken for a proper membrane. Sometimes a leſſer branch goes along the centre of the nerve to the retina, and is in like manner ramified through it. It is certain, that from theſe branches the minute pellucid ones of the vitreous tunic are produced, as well as the poſterior artery of the lens. The centre of theſe arteries, entering the retina, is the celebrated *porus opticus* of the ancients.

DXXVIII. The veins of the eye, in general, ariſe from the ophthalmic vein, which here comes from the vein of the face; and, going out of the bony orbit, is inſerted into the cavernous ſinus[145]. The internal veins of

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[144] Theſe do not agree with the late obſervations made by Mr Walter and myſelf. I have carefully followed the central artery in its courſe after diſſecting the optic: it paſſes, without giving any branch to the retina, through the vitreous humour, and there very tender threads go off; but the whole trunk of the central artery ends very prettily upon the poſterior ſurface of the capſule of the lens, as was painted in my publication in the New Gottenburgh Commentaries.

[145] Since the veins of the eye had been neither well deſcribed nor elegantly painted, I was led to make new drawings of them along with the new work of the immortal Zin. But that great and indefatigable anatomiſt Walter anticipated the honour, and has rendered almoſt ſuperfluous any of my drawings, one or two excepted, which have now come out.

In two places, and by two ways, the venous blood of the eye is returned, partly into the ſinus cavernoſus, in which is inſerted the poſterior part of the vena magna ophthalmica; which Walter calls *ophthalmica cerebralis*, and I the *ſuperior magnus*. It collects all the blood from the glandula lachrymalis, ethmoidal veins, the ciliary and muſcular ones coming from the ſuperior part of the eye. It is partly poured into the great facial vein; into which the anterior part of the eye are fewer in the middle of the ſclerotica, which they perforate with larger trunks, and form buſhes or trees of a roundiſh figure, which commonly keep the middle of the baſis of the tunica choroides: ſome of them, which are long, reach even to the origin of the uvea: others, in the fore part, are ſimilar to arteries: another central vein, like an artery, goes to the retina of the optic nerve. The pellucid or watery veſſels differ not in their courſe from thoſe which convey blood. There are alſo lymphatic veſſels ſaid to have been ſeen by ſome in the retina; but the obſervation has not been often enough repeated for us to depend on it.

DXXIX. So far with reſpect to the anatomy of the eye; but that the action of this organ lies wholly in the reception of light, excepting only a few doubts, appears very plainly from phyſical and mechanical experiments. Light then is a matter either the ſame with, or very nearly approaching to, that of fire[146], extremely fluid and ſubtile, penetrating through all even the hardeſt bodies, without receiving alteration from any length or diſtance in its courſe; moving with ſuch a very great velocity, as to run through the diſtance between the ſun and earth in the ſpace of about eight minutes and thirteen ſeconds. The light we have in our atmoſphere proceeds either from that of the ſun, whoſe body ſeems to have the power of impelling to us, in right lines, the matter of light, which is confuſedly ſpread

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of the great ophthalmic vein carries the blood from the anterior part of the eye, the tunica conjunctiva, and palpebræ. Another ophthalmic vein has been added to theſe, called by Walter *ophthalmica facialis*, and by me *ophthalmica inferior minor;* which tranſmits the blood of the inferior parts of the eye, the ciliary and muſcular veins, partly into the major ophthalmica, and partly through a deep branch into the vena facialis.

[146] If we compare the late experiments of Mayer, Weigel, Bikker, and Herbert, with thoſe of Sachs and Boerhaave, we may aſſert with the greateſt probability, that there is a peculiar matter in nature, which is fitted for producing heat and ſpreading light, according to the different motion and direction of its particles.

ſpread around; or elſe it proceeds from ſome other ignited point or lucid body; from whence the rays ſpread every way, as from a centre to all points of a large ſphere, ſo as to fall upon the ſurfaces of bodies; from whence again it is reflected into the eye, from the enlightened ſurfaces, in angles equal to that of their incidence, ſo as to render the bodies from whence it thus flows to the eye both viſible and of ſome colour.

DXXX. It is now ſufficiently evidenced from experiments, that light is compoſed of rays in right lines, almoſt without any phyſical breadth or thickneſs; and yet, that each of theſe rays is again ſeparable into ſeven other permament and immutable rays of a leſſer kind. The known properties of theſe rays are, that all of them, conjoined together, conſtitute a white beam; which, being refracted by the minute ſurfaces of bodies, are ſubdivided into rays of a red colour, which are more conſtant or permanent, hard, and leſs refrangible; next to which follow thoſe of an orange, of a yellow, green, blue, and indigo or violet colour; of which thoſe are always weaker and more refrangible, which are farther diſtant in order from the red rays[147]. A ſhadow ariſes from a deficiency in the reflected rays. Thoſe primitive rays, variouſly compounded together with ſhade, make up all the variety of colours.

DXXXI. The colours, then, which ſeem proper to bodies, ariſe hence; that the minute ſurfaces of their conſtituent ſolid particles, by which their pores or vacuities are limited, do, according to the difference of their thickneſs, denſity, &c. reflect or ſeparate the rays of light, ſo as to ſend more of one kind or colour to the eye than another; whilſt moſt part of the remaining rays are loſt by repeated reflections within the pores of the ſubſtance: ſo that the ſtrongeſt and thickeſt particles reflect a white colour; thoſe next in denſity and ſize, a red colour; till at laſt the minuteſt ſurfaces reflect a violet colour. Thoſe bodies are opake, which retain the rays within their ſubſtance, without permitting any to paſs through them: which ſeems to follow from the largeneſs and the number of the pores, to the ſides of which the light is attracted; which pores are filled with ſome matter that has a power of refraction, different from that which the light ſuffers from the parts of the body itſelf. Theſe principles we embrace, till a new theory that places the diverſity of colours in vibrations of different celerities ſhall be better eſtabliſhed; neither is it our buſineſs to concern ourſelves with this matter.

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[147] To the hypotheſes concerning the variety and riſe of colours, according to Newton, Mariot, and Euler, the late Mayer has added a new and very probable opinion, that there are only three primary colours, yellow, blue, red; traces of which conjecture are now found in Lomonoſs, but more extended by Lambert and Erxleb, by means of the elegant pyramids of colours ſo called.

DXXXII. Theſe rays, falling obliquely upon the ſurface of liquors of various denſities, paſs through them with a change in their direction, by variouſly receding from or approaching nearer to a perpendicular: and this is called their *refraction*. In general, the denſer the medium, the more are the rays bent towards the perpendicular; excepting only inflammable liquors, which, by a peculiar property, draw the rays more to a perpendicular than in proportion to the denſity of the liquor. The proportions of the angles of incidence to thoſe of refraction are obſerved to be conſtant enough; ſo that the ſine of the radius of refraction from air into water is to the ſine of the angle of incidence as 3 to 4: and in the radius, paſſing from air into glaſs, the ſine of the incidence is to that of refraction as 17 to 11; and from water into glaſs, as 51 to 44 [148].

DXXXIII. Rays, which come through the air with but little divergency, (as thoſe of the ſun do on account of their immenſe diſtance, or as in general do any rays that come from the diſtance of above 100 feet), falling out of the air upon denſer bodies, ſpherically convex, are reflected to greater angles, as of 48½ degrees; nor are they under that meaſure. If the angles are ſmaller, and they penetrate the refracting medium, they are there ſo refracted, as to meet together in one point, which is called their *focus*. This point always falls within the axis or radius that is perpendicular to the ſurface; whence it becomes permanent and unchangeable. So that the focus of rays, paſſing from air into a ſphere of water, will be diſtant from the axis one ſemidiameter of the ſphere; and in a globular glaſs, it will be diſtant a fourth part of the diameter: but in a convex lens of glaſs, that is, part of a ſphere not leſs than thirty degrees, and equally convex, the focus will be likewiſe diſtant one ſemidiameter; yet ſo that the rays will meet, not in a ſingle point, but in a little circle.

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[148] We cannot read the works of Smith, Kaeſtner, Prieſtley, and Klugel, without admiration, where they have explained the uſe of optics, in letting us underſtand the theory of animal viſion.

DXXXIV. Therefore the rays of light, whether direct or inflected, fall in ſuch a manner upon the tunica cornea of the eye, as to form a moſt ſharp cone betwixt the lucid point and the membrane upon which they are ſpread: the baſis of which cone will be the ſurface of the cornea, and the apex in the radiant point; yet ſo that all rays in this cone may, without any ſenſible error, be reckoned parallel with each other. Among theſe, there are ſome rays reflected back from the cornea, without ever penetrating the ſurface; namely, all ſuch as fall upon that membrane in a greater angle than that of forty degrees. Others, which enter the cornea at very large angles, but leſs than the former, and fall in betwixt the uvea and ſides of the cryſtalline lens, are ſuffocated or loſt in the black paint that lines the uvea (DXII.) and the ciliary proceſſes (DXIV.); but thoſe rays only fall upon the ſurface of the lens, which enter the cornea at ſmall angles, not much diſtant from the perpendicular, or at moſt not exceeding twenty-eight degrees. By this means, all thoſe rays are excluded which the refracting power of the humours in the eye could not be able to concentrate or bring together upon the retina; without which they would paint the object too large and confuſedly.

DXXXV. Thoſe ſlender rays, therefore, coming thus to the thick cornea, which is denſer than water, and forms the ſegment of a ſphere, ſuffer thus a greater power of refraction, and paſs through it in a more conſiderable degree towards the perpendicular; namely, about a fourth part: but theſe rays falling with but little convergency upon the aqueous humour, which is ſmall in quantity and almoſt like water, making there no focus, becauſe of the nearneſs of the humour to the cornea, go on nearly parallel, or little converging, to the next adjacent ſurface of the very pellucid or cryſtalline lens; becauſe their divergency was conſiderably corrected by the refracting power of the cornea. Moreover, the cornea being convex, and part of a leſs ſphere than that of the ſclerotica, receives and collects a greater number of rays than if it was flatter with a leſs ſurface.

DXXXVI. The refracting power of the cryſtalline lens, which exceeds that of water, may be underſtood from its greater hadneſs and weight; although we have no certain meaſure. In this lens, therefore, and more eſpecially in is poſterior very convex ſide, the rays will converge greatly, and paſs thence into the vitreous body.

DXXXVIII. This vitreous body is denſer than water in which it ſinks to the bottom; but rarer than the cryſtalline lens; and continues to bend the rays a little more gently towards the perpendicular, till at length the rays coming from the point of diſtinct viſion, are concentrated into a very ſmall part of the retina, where they paint an image of that object from whence they come; but in a poſition inverted, from the neceſſary decuſſation or croſſing of the rays. The manner in which the images of objects are thus painted, may be ſeen experimentally in an artificial eye, or by a natural eye when the back part of the ſclerotica is cut off, and a piece of paper placed to receive the object. But the image we ſee is painted on the outer ſide from the optic nerve within the bounds of the viſual axis; yet ſo that it is not a mere point, but has ſome degrees of breadth; ſince we ſee many objects at once, whoſe images muſt be in diſtinct points of the painted field. And there an object is ſeen moſt diſtinctly, becauſe the rays arrive thither nearly perpendicular. But frequently this point of viſion does not fall on the ſame place on both of the eyes. When the lens has been couched or diſplaced, the vitreous body, with a weaker refracting power, uſually ſuffices to bring the viſual rays together to a focus.

DXXXIX. Is it altogether falſe that the object is painted on the retina? Or is this picture made on the choroïdes? Is this new opinion confirmed by an experiment, by which it is found that the place where the optic nerve enters is blind? and which is thus explained, that there is in that place no choroides but the bare retina, and that thence there is no viſion. But this is repugnant to a very well known obſervation, namely, that the retina is a moſt ſenſible nervous medulla; and that the choroides conſiſts almoſt entirely of a few ſmall nerves, and of veſſels moſt certainly blind. This is likewiſe contradicted by the very great variety of the choroides in animals; the equally great conſtancy of the retina; and the black ſpots, which, even in man, obſcure the exterior ſurface of the retina. But by this experiment we know the reaſon why the optic nerve is not inſerted into the axis of the eye, but into its ſide. For thus, except only in one ſingle caſe, where there is an impediment in the concourſe of lines drawn through the centre of the optic nerves, the one eye ſees and aſſiſts that whoſe blind ſide is turned towards the object.

DXL. But ſince the neceſſary offices of human life require a diſtinct object to be painted upon the retina, not only by the rays which come from one certain diſtance, but likewiſe by rays which come from very different parts more or leſs diſtant; therefore, it is to be believed, that the neceſſary change is produced in the eye by its own proper cauſes. Other famous anatomiſts have ſuppoſed the lens moveable by the powers before mentioned (DXIX. DXXIII.) This art of ſeeing diſtinctly is ſaid to be learned by experience, it being unknown to an eye lately couched of a cataract. Alſo, in an artificial eye, the uſe and neceſſity of this motion, it is ſaid, may be plainly perceived. Therefore too great a divergency of the rays, as in thoſe which come from objects very cloſe to the eye, is corrected by a removal of the lens farther from the retina, ſo as to bring the focus of the diverging rays upon the retina itſelf, which would otherwiſe have fallen behind the eye; for the refracting power of the eye being determined, that which will unite the focus of rays coming from the diſtance of three feet, ſo as to make them fall perfectly upon the retina, will not be able to collect together into the ſame point thoſe rays which come from the diſtance of three inches; and rays ſtill more diverging will meet together yet farther behind the eye, if they are not collected together by a greater refracting power.

DXLI. But thoſe rays, which come from parts very remote, and which may be therefore counted parallel, will meet together before the retina, in the vitreous body; and again ſeparate according to the nature of rays from the point of concourſe, as if it was a lucid point: to remedy which, therefore, it is probable that thoſe powers (DXXIII.) remove the cryſtalline lens back from the cornea nearer to the retina; that the rays, which come together from a certain diſtance to the lens, may be alſo united together at a certain proportionable diſtance on the retina. For an eye, that will collect the rays coming from ſeven inches, ſo as to unite them on the retina, will collect thoſe together before the retina which come from a diſtance of three feet. It was therefore perfectly neceſſary for the eye to be made thus changeable, that we might be able to ſee diſtinctly at various diſtances. But the point of diſtinct viſion is in that part of the retina where the given object is

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painted in the leaſt compaſs poſſible. The powers cauſing the viſual rays to unite or converge on the retina, are often very different in the two eyes of one and the ſame perſon, ſo as to render one eye nearly preſbyoptical or long-ſighted, and the other myoptical or ſhort-ſighted.

DXLII. Theſe and other things ſimilar are commonly received and taught more eſpecially by the mathematicians, who more readily perceive the neceſſity of theſe changes. But yet there is no power in the human eye which can either move the cryſtalline humour out of its place, or compreſs it. But we do not perceive this faculty in ourſelves: for we move a book nearer to our eyes when it is too far off, ſo as to appear confuſed; which we would have no occaſion to do, if by changing the internal figure of the eye we could correct the fault of the diſtance: and through a ſmall hole, we perceive an object only ſingle in the point of diſtinct viſion, but double in every other. Perhaps the contraction of the pupil may do ſomething, by which we can perceive more diſtinctly ſuch objects as are near.

DXLIII. But this artifice of the eye is not ſufficient in all perſons. For there are now a greater number of people than formerly employed in a ſtudious or ſedentary life, and taken up with the obſervation of more minute objects; by which the cornea is rendered more convex and denſe, and the cryſtalline lens more ſolid and of leſs ſegments; while the eye itſelf, by the weight of the humours, is more elongated, and the reſt of the humours themſelves are probably more denſified: many or all of which circumſtances attend the eyes of one perſon. In ſuch, the iris is ſenſible in a ſmall light; whence, by winking, or ſtraining the eyelid, they are denominated *myopes*, ſhort or near ſighted. In theſe, the point of diſtinct viſion is very near to the eye, from one to ſeven inches from before the cornea; but they ſee remoter objects more obſcurely, without being able to diſtinguiſh their parts. The reaſon of this is evident; ſince, from the forementioned cauſes, there is a greater refracting power of the humours, by which the diſtant and conſequently parallel rays are obliged to meet in their focus before the retina; from whence ſpreading again, they fall upon the retina in many points. Thus alſo to a good eye, the ſenſe of objects which are too near the cornea is confuſed; becauſe the rays coming from thence are ſpread all over the retina, without being collected towards the centre.

DXLIV. The remedy for this fault in the ſight is to correct it in its beginning, by viewing diſtant places, by keeping the eyes from minute or near objects, and by the uſe of concave glaſſes; or by viewing things through a ſmall hole, by which the light is weakened. When the diſorder is confirmed, the remedy is a concave lens, which takes off a degree of the refracting power in the humours, cornea, and cryſtalline lens, in proportion as it is more concave; by which means the focus of rays from remote objects is removed farther behind the cornea, ſo as to fall upon the retina. This glaſs ought to be a portion of a ſphere, whoſe diameter is equal to the diſtance of diſtinct viſion from the naked eye, ſquared by the diſtance of diſtinct viſion in the armed eye, and divided by the difference betwixt them. Age itſelf advancing, gives ſome relief to the ſhort-ſighted; for children are in a manner naturally myoptical: but, as the eye grows older, it becomes flatter, in proportion as the ſolids grows ſtronger; and, contracting to a ſhorter axis, the converging powers of the lens and cornea are diminiſhed.

DXLV. Another diſorder of the ſight, contrary to the former, troubles people who are often looking upon very diſtant objects, and is more eſpecially familiar and incurable in old people. In ſuch, the cornea and cryſtalline lens are flatter, and the humours of the eye have a leſs refracting power. Hence near objects, whoſe rays fall very diverging upon the cornea, appear confuſed; becauſe the converging or refracting powers of the eye are not ſufficient to bring the rays together in a focus upon the retina, but the rays go on ſcattered through the retina, and through the point of their pencil behind the eye; from whence viſion is confuſed. The point of diſtinct viſion among preſbyopi, or old or long-ſighted people, is from the diſtance of fifteen inches to three feet.

DXLVI. Such perſons are, in ſome meaſure, relieved by looking through a black tube held before the eye; by the uſe of which the retina grows tenderer, and the rays come to the eye in a parallel direction. The remedy here is a convex lens of glaſs, which may cauſe the rays to converge and unite together ſooner in a focus, that it may not fall behind the eye, but upon the retina. The diameter of the ſphere, of which ſuch a lens ought to be a portion, is determined as before (DXLIV,) There is no hope from age, which increaſes the malady.

DXLVII. The medium betwixt ſhort and long ſighted is the beſt, by which a perſon can ſee diſtinctly enough objects that are both near and remote; and of this kind we reckon an eye that is able to read diſtinctly at the diſtance of one foot. But to this are to be added other neceſſary conditions; ſuch as a perfect clearneſs of the humours; a due mobility of the eye itſelf, and its parts; a ſenſibility of the pupil and retina, neither too tender nor too tough.

DXLVIII. But the mind not only receives a repreſentation of the image of the object by the eye, impreſſed on the retina, and transferred to the common ſenſory or ſeat of the ſoul; but ſhe learns or adds many things from mere experience, which the eye itſelf does not really ſee, and other things the mind conſiders or interprets to be different from what they appear to her by the eye. And, firſt, the *magnitude* of an object is judged of by an optical angle intercepted; as the baſis of a triangle betwixt the cornea, and as the point of a cone betwixt the radiant object. From hence, things very near ſeem large, and remote objects ſeem ſmall. Hither may be referred the power of microſcopes, by which objects are made to appear to us ſo much larger, as the diſtance of the focus of the lens or magnifier is leſs than the diſtance of diſtinct viſion; when, in reality, they do not appear larger, only more diſtinct and lucid; whence the mind judges them to be nearer,

DXLIX. The ſtrength of viſual light likewiſe is proportionable to the ſame angle, in the external day-light; and the multitude or number of the rays, joined with the ſmallneſs of the ſeat which they affect in the retina, occaſions near objects to appear brighter, and diſtant objects more obſcure; or if remote objects appear bright by their own light, the mind repreſents them as large, near at hand, or both.

DL. The *place* of a diſtant object appearing to one eye, is reckoned to be in a line comprehended by two other ſtraight lines drawn to the extremities of the body. If the ſame body is looked upon with both eyes, it will then ſeem to be in the concourſe of two lines drawn through the axis of both eyes to that object.

DLI. *Diſtance* we cannot perceive; and if a blind man, who never ſaw, ſhould by any means be reſtored to ſight, he would imagine every thing he ſaw to touch his eyes. Even we who are accuſtomed to judge by ſight, make many fallacious conjectures concerning the diſtance of objects: but concerning this we judge as well from the known diminution of the bulk of the body, as from the leſſer ſtrength of the light, and faint image of the object whoſe parts we are leſs capable of diſtinguiſhing, and from the number of bodies interpoſed, whoſe diſtance is known.

DLII. The *convexity* or *protuberance* of a body is not ſeen; but is afterwards judged of by experience, after we have learned, that a body, which is convex to the feeling, cauſes light and ſhadow to be diſpoſed in a certain manner. Hence it is, that microſcopes frequently pervert the judgment, by tranſpoſing or changing the ſhadows. The ſame alſo happens in that phenomenon which is not yet ſufficiently underſtood, by which the concave parts of a ſeal are made to ſeem convex, and the contrary.

DLIII. The viſible *ſituation* of the parts of an object, are judged by the mind to be the ſame with that which they naturally have in the object, and not the inverted poſition in which they are painted upon the retina. But it is certainly a faculty innate or born with the eye, to repreſent objects upright to the mind, whenever they are painted inverted upon the retina: for new-born animals always ſee things upright. And men who have been born with cataracts, without ever being able to ſee, are obſerved, upon couching the cataracts, to ſee every thing in its natural ſituation, without the uſe of any feeling, or previous experiences.

DLIV. One thing which impoſes upon the mind, is the continuance which external ſenſations make, during almoſt the ſpace of a ſecond of a minute, after they have been conveyed to the ſenſorium by the eyes; whence they are repreſented to the mind as objects really preſent. From hence proceeds the idea of a fiery circle from the circumrotation of a lucid body; and from hence proceeds the continuance of the ſhining image of the ſun, and ſometimes of other bodies, after they have been viewed by the eye.

DLV. Do we perceive only that object diſtinctly which is directly before that part of the retina which ſees moſt diſtinctly? And does the eye perſuade itſelf, that it ſees many objects at a time, partly from the duration of the ideas, and partly from the quickneſs of the motions of the eye? Concerning the moſt diſtinct viſion, this is moſt certain; but we cannot affirm it of that which is leſs diſtinct. Why do we ſee only one object with two eyes? Becauſe the ſenſation becomes one, and without difference, when we have ſimilar impreſſions of two objects. For, even without the concourſe of optic nerves, inſects who have numerous eyes perceive objects ſingle. Hence the images of two objects excite only one ſenſation, when they fall upon the ſame point of the retina; but two ſenſations ariſe from one object, when the images fall upon different parts of the retina. Whence proceed diurnal and nocturnal blindneſs? The former is common to many nations living in the warmeſt climates, under the brighteſt rays of the ſun, and to old men. The other happens in inflamed eyes, and young men of a hot temperament, and hence endowed with eyes vaſtly ſenſible. Whence do animals ſee in the dark? From a large dilatable pupil, and tender retina; a ſhining choroides, and one which reflects the light very ſtrongly. Why are we blind when brought out of a ſtrong light into a weak one? Becauſe the optic nerve, having ſuffered the action of ſtronger cauſes, is incapable of being moved by weaker ones. Whence have we a pain, by paſſing ſuddenly from a dark place into the light? Becauſe the pupil, being widely dilated in the dark, ſuddenly admits too great a quantity of light before it can contract; whence the tender retina, which is eaſily affected by a ſmall light, feels, for a time, an impreſſion too ſharp and ſtrong. Whether ſee we with one eye, or with both? Moſt frequently with one, and more eſpecially the right eye: but when both are employed together, we ſee more objects, and more plainly; and we alſo diſtinguiſh more points of the ſame object, and judge better of their diſtances.

CHAP. XVIII.

Of the INTERNAL SENSES.

DLVI. THE organs of the ſenſes have hitherto been conſidered and diſcuſſed ſeparately. We now ſee, that it is common to them all, that the tender pulp of the nerve, being ſtruck or impreſſed by external objects, conveys, by the nervous ſpirits, ſome change to that part of the brain where the impreſſed fibres of the nerve firſt ariſe from the arteries (CCCLXXII.) We know nothing more, than that new thoughts are thus excited in the mind, whenever ſuch a change, produced upon any organ of ſenſe, is conveyed to the firſt origin of the nerve which receives the impreſſion. For thought is not the expreſs image of the object, by which the ſentient nerve is affected. What in common has the idea of redneſs with a ſlightly refrangible ray, ſeparated from the ſeven portions of the whole ray? Nor is it conſiſtent with optical principles, that an object, painted by rays upon a ſoft white nerve, can be, in a long tract of perfect darkneſs, conveyed through a very opaque body to the origin of the optic thalami. There is nothing in the pain of burning that can repreſent to the mind a ſwift and ſubtile matter violently moved, by which the continuity of the nervous threads are deſtroyed. There is nothing in the idea of a ſharp ſound, from a cord of a certain length, that can inform the mind the ſaid cord trembles 5000 times in the ſpace of a ſecond. Neither does taſte teach us that the cryſtals of ſea-ſalt are of a cubical figure. Again, though a motion is impreſſed on the brain, from the ſenſation perceived by the body, the mind neither perceives this motion, nor the tremors of ſounds, nor the percuſſions of the rays of light, but ſomething perfectly diſtinct from this motion. But it is eſtabliſhed as a perpetual law by the Creator, that certain changes, made firſt in the nerve, and then in the common ſenſory, ſhall produce certain new correſponding thoughts in the mind, which have an indiſſolvable connection with each other; ſo that, although what we perceive in the world be arbitrary, yet that it is real, and not falſe, appears plainly from the perpetual agreement of ſimilar thoughts ariſing from ſimilar affections of the ſenſitive nerves, in all perſons at the ſame time, from one object, or in one perſon at different times.

DLVII. During the time of our perceptions, therefore, five very different beings are joined together: the body which we perceive; the affection of the organ of the ſenſory by that body; the affection of the brain ariſing from the percuſſion of that ſenſory; the change produced in the mind; and, laſtly, the mind's conſciouſneſs and perception of the ſenſation.

DLVIII. It appears from certain experiments, that the firſt origin of every perceiving nerve is always diſtinct; and that the change which is firſt excited by the external object in the ſaid nerve (DLVI.) continues in the origin of that nerve for a conſiderable time; and alſo that thoſe changes are ſo claſſed and laid up within the ſaid part of the brain, that thoſe are neareſt together, which were either contemporary, or nearly ſo, or which have ſucceeded next in courſe; or laſtly, which have a relation to the ſame ſubject, or were excited by ſimilar objects: inſomuch, that it is certain, new ſpecies or ideas are always conveyed again to the ſame part of the brain where others of the like kind are reſerved: for otherwiſe the arbitrary ſigns of words and letters would never be able to renew the ſame old ideas again in the memory; nor could diſagreeable ideas, returning into the mind, without the aſſiſtance of external objects, reproduce the ſame effects, as would the diſagreeable objects themſelves; nor, otherwiſe, could there be ſo conſtant and manifeſt a connection of analogous ideas, which moſt powerfully occur in dreams, according to the corporeal cauſes which then remarkably act in the brain. Whether or no do imagination and memory depend on this conſervation of ideas? Finally, thoſe changes in the ſenſorium, which many term paſt or reſerved ideas, are, for diſtinction's ſake, by us called the *footſteps* or *traces* of things, which are lodged or engraved not in the mind, but in the body itſelf, by certain notes or characters, incredible in their minuteneſs, and infinite in their number, recorded after an inexpreſſible manner in the medulla of the brain. Amongſt theſe characters, ſuch are more eminently and diſtinctly preſerved as were received, firſt by the ſight, and next by the hearing; for thoſe of the other organs are more confuſed and irrevocable by the will. And both the traces and their ſigns are preſerved; the latter more eaſily; the former, however, ſo far, that a painter can eaſily expreſs with his pencil upon canvas, an image of a face ſimilar to one which he is accuſtomed with, and which is impreſſed on his mind.

DLIX. *Imagination*, then, is whenever any ſpecies, preſerved in the common ſenſory, and in preſent perception, excites ſuch other thoughts in the mind as would ariſe if the perceiving nerve that gave the firſt birth to the ſaid ſpecies was itſelf affected or changed. This definition is confirmed by examples of the great ſtrength of fancy in certain perſons, and thoſe who are delirious; but in every body, in the inſtance of dreams, in which thoughts ariſe in the mind, occaſioned by the corporeal ſpecies reſerved in the brain, ſo as to be not at all weaker than thoſe which were firſt formed by the change in the ſentient nerve, from the external objects. Even more, the attention and reſt of the mind, with the abſence of all external objects, will often obtain a ſtronger aſſent from dreaming, towards the traces impreſſed in the brain, than that which is given from the mind by the perceptions which are excited from external objects: for the will is more powerfully determined in thoſe who dream, than in thoſe who are awake, ſo as often to perform certain actions by the voluntary muſcles, while they are aſleep, which they never can perform awake, even though the ſame nerves were more ſtrongly affected by the real objects. From hence we may underſtand, how it is poſſible the internal ſpecies, which are very ſtrong in a delirium, may ſo impoſe upon the mind, as to make her miſtake them for the perceptions of external objects; as, for example, in the fiery ſparks which are excited by preſſing the eye and optic nerve; in the redneſs ſeen by the eye when it is ſhut; in the vertigo or rotation that ariſes from a motion of the retina, which we aſcribe to the external objects themſelves; in the duplicity of ſight, &c.

DLX. But *memory* is, when any internal former thought of the mind, or the ſpecies perceived and preſerved in the brain, from external objects (CCCLXXII.), repeat or excite again other perceptions in the mind. And here the perceptions are commonly weaker than in the imagination, being almoſt only certain arbitrary ſigns conjoined together, with the idea that was firſt perceived in the mind: for the memory hardly repreſents the images and pictures of things to the mind; only the words or ſigns, and certain attributes, together with the general heads of ideas; for which reaſon, they move the will with leſs force: but it appears from the obſervation of thoſe changes which happen in the memory, that ſuch as ariſe from the external ſenſes remain longeſt in the brain; and ſometimes, if they made a ſtrong impreſſion, they may for ever, and in all ages of life, be repeated to the mind; but they are weakened, and in a manner blotted out in time, by degrees, unleſs the repreſentation be renewed again to the mind, either from an external object, or from the mind itſelf recalling the ſame change again into memory: ſo that, without this repetition, at laſt the change or impreſſion will be in a manner eraſed and quite loſt; and will never be able to be drawn in again to the mind, whenever ſhe repeats ſuch other thoughts as had naturally any connection with the former. This deſtruction of new and different ſpecies, conveyed to the ſenſorium, is evident, not only from the effect of time, but likewiſe from cataleptic diſorders; which ſometimes, after a conſiderable interval of time, go on with the ſame train of thought which the diſeaſe had interrupted. But ſometimes all of them will be ſuddenly deſtroyed by diſeaſe, in which the brain is any how compreſſed, either from the blood or other cauſes. Such a compreſſing cauſe, acting on ſome part of the common ſenſory, blots out a correſponding number of the ſpecies from the mind or memory, whether they be certain or all kinds of words, or even the characters by which we expreſs words; or, laſtly, the characters of our friends, and neceſſaries of life: yet all theſe ſpecies are often again renewable to the mind, whenever the compreſſing cauſe is removed. But the ſtrength and duration of an idea depends upon its being either unuſual, of a ſtrong action, or greatly conducing either to in-

increaſe or leſſen our felicity; or, laſtly, from being joined with great attention from the mind, and often repeated: all which circumſtances being conjoined, may render the ſpecies ſo ſtrong to the mind, that ſhe will afterwards receive the perception of them, as if they came from external objects, in the manner we obſerve in mad people.

DLXI. Moreover, if we review the hiſtory of human life, it will appear, that in the beginning of our infancy, we have hardly any memory; only ſimple perceptions, that ſoon vaniſh: which, nevertheleſs, do for the preſent excite ſtrong thoughts or impreſſions in the mind, as we learn from the clamours of infants. But afterwards, the memory is perfected by degrees, and the ideas received from perſons moſt beloved and familiar to the infant remain impreſſed in the mind; while, at the ſame time, the imagination likewiſe increaſes in proportion, ſo as to be often very powerful in young children; as we ſee, for example, in frights, which in no age produce more violent or fatal effects. From thence forward, as the number of our ideas increaſes, the faculty of preſerving thoſe paſt, weakens; and, at the ſame time, the power of the imagination is more torpid or ſluggiſh: till at laſt the former almoſt periſhes, and the ideas, which are received but a ſhort time, eſcape from the brain; while, at the ſame time, the imagination, which is a kind of memory, languiſhes in proportion.

DLXII. But ſince the perceptions thus formed in the mind, produce in her various changes, which are perfectly free and diſtinct from any corporeal faculty, we ſhall briefly add ſomething concerning them, ſo far as may ſuffice to the purpoſes of phyſic. The office of *cogitation* in the ſoul, is to attend to the ſenſations which are either brought by the ſenſes, or recalled by the imagination; frequently alſo to the ſigns alone which recur into the mind. *Attention* then is ſaid to operate when the mind obſerves one and the ſame idea alone, and for a longer time together. The compariſon of two or more ideas brought to the mind, is called *reaſon*; as the ſimilitude, diverſity, or relation perceived by the compariſon, is called *judgment*. The principal cauſe of *wiſdom* and *invention* lies in a ſlow examination of the ideas, conſidered in the relation of all their parts one to another in the mind, while, neglecting all other objects, ſhe is employed with a ſtrong attention only upon that which is under examination. From hence proceeds that efficacy of ſolitude and darkneſs in making difficult calculation; with the more exquiſite attention of blind people to the nature of ſounds; and of thoſe who are deaf, to colours. The ſource of *error*, is ſome neglect in contemplating the whole idea, or the making an eſtimate of it from only a part of its note or character, or from a leſs congruous connection of ſome ideas with others that are diſtinct, but only related by accident, external cauſes, or affections.

DLXIII. The integrity or *ſoundneſs* of the judgment depends upon a perfect and healthy conſtitution of the brain[149]. For the fabric of the encephalon being changed,

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[149] In medical pſychology, differing only in a few remarks from that ſcience which is ſimply called *pſychology*, the actions of the ſoul or mind are inveſtigated. A more elegant ſubject, and more worthy of attention, cannot be imagined, than the thinking principle in man; whether we conſider the difficulty of the inveſtigation, the delight which the ſtudy of it affords, or the utility which it propoſes in life. It is a very well known point, that all bodies, endued with the perfect life which we uſually call *animal*, do not perform and exerciſe theſe functions of the mind in one and the ſame manner, degree of perfection, multitude of ſymptoms, and attributes, for the advantage of public ſociety, for the like and ſame reaſon, and, what ſeems peculiar to me, in the hope, knowledge, and remembrance either of future proſperity, or adverſity. All animals, quadrupeds and mammalia in particular, have ſome or other of the functions or operations of the mind in common with man: ſome ſeem to be proper to man alone, being bleſſed with the pleaſure of ſociety, and of education and ſpeech; but in men themſelves, there is in fact a wonderful difference both in theſe faculties and the exerciſe of the mind itſelf.

For although, among the various ways in which the human mind can act and exerciſe its own proper functions, and ſignify its government over the body, we confine ourſelves to two, we ſhall however obſerve ged, either by compreſſure, irritation, or a deficiency of blood, confounds all the uſe of reaſon; occaſions the ſtrong internal ſpecies of the brain to be repreſented to the mind as if they came from external or real objects; breaks the connection of the ideas, ſo that the

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ſerve a very great diverſity. Under this head belongs, (1.) The power of directing, exciting, and limiting the whole body, and many of the corporeal actions; whether our will be governed by inſtinct alone, which man frequently, though not always with ſafety, and brutes almoſt always indulge; or whether it be inclined by reaſon and underſtanding. (2.) The power of learning, of amplifying our knowledge, making new diſcoveries, meliorating human ſociety; and, in a word, of arriving at that pitch of felicity to which the divine wiſdom allows us to aſpire. The riſe and preſervation of ideas, the power of memory and imagination, and, by means of attention, the inherent bleſſing of thinking, comparing ideas, and paſſing judgment, &c. are all to be numbered in this claſs.

Upon rational conſideration, why theſe mental functions are exerciſed in ſo different a manner, both by men and brutes, a twofold claſs of cauſes is to be aſſigned; the one innate in the body; the other depending upon external cauſes, and their various methods of acting.

I. The firſt claſs of cauſes, allowing no change, unleſs in the moſt rare examples, ſuppoſes ſuch a conſtitution of the body, that is fit for performing its functions, and for receiving impreſſions from external cauſes. Of conſequence, in particular

a, Not only the preſence, but at the ſame time the due proportion, of the organs, muſcles, inſtruments, and certain viſcera is requiſite.

b, The neceſſary proportion of the brain and nervous ſyſtem to the whole body, and its parts in particular, and the interior aptitude of the ſame for performing its functions. Here we refer (1.) To the quantity and magnitude of the brain relatively to the whole animal body. Man has the largeſt brain among all the mammalia, a few excepted: compared with the weight of the whole body, 125 lib. it is $3\frac{3}{4}$, $4\frac{1}{2}$, 5 lib. and therefore proportionally as 30, or 26, or 24, to 1. The leaſt brain I ever ſaw was in a woman who was a great fool, and it was $1\frac{3}{4}$ to 100, the weight of the whole body. But in youth this proportion is changed, viz. the younger a perſon is, the more brain he has; in proportion almoſt as 1 to 8. The inference, therefore, that the powers of the mind increaſe with the greater quantity of brain, which the fœtus ſtate denies, is only conſiſtent with another attribute. (2.) To the different relation and proportion of each ſubſtance of the brain. The human brain is full of furrows and irregularly encircled portions. The younger man and all animals are, the more cortical ſubſtance is preſent, more than a the mind cannot compare them together; and is conſequently unable to judge of, or foreſee, their proportions, differences, or conſequences; ſtarting immediately from one idea to another that has no kind of relation: or laſtly, the actions of the ſenſes being either weakened or aboliſhed, and the brain in a manner deprived of its corporeal ſpecies, the man is reduced to the ſtate of an idiot or a plant. But the powers of external bodies alſo have a conſiderable influence in changing the ſpecies of objects which the mind acquires by the ſenſes; for the air, way of life, food, and cuſtoms, either help or diminiſh the ſoundneſs of the judgment, the force of the imagination, and the ſtrength of the memory.

DLXIV. Finally, as theſe ideas are either indifferent to us, or elſe conduce to the loſs and increaſe of our felicity,

a half of the whole: it is diminiſhed gradually as age grows up, and a great part of it is changed into medullary; which change, in fact, does not a little contribute to the increaſe of the mind. (3.) We muſt conſider the very ſpecific gravity of the brain in brutes and men at different ages. I have always found, and many obſervations have confirmed it, that a cubic inch of an infant's brain was ſpecifically lighter than the ſame of an adult; the ſame alſo held good of the more ſtupid ſort of men and quadrupeds. (4.) At the ſame time, we muſt remark the different proportion of the brain to the cerebellum; for moſt brutes have more cerebellum, with reſpect to the brain, than any man. It is the ſame caſe with the nerves. If you want a due perfection in this part of the body, you never can correct it, nor add any thing to the functions of the mind.

II. The latter claſs of cauſes comprehends thoſe bleſſings through which we acquire an increaſe of knowledge, and in general upon which the whole knowledge of man, our proſperous and adverſe fortune, &c. depend. We may reckon of importance here, *a*, The multitude of ideas which our ſenſes ſupply us with, and which we may augment by the imagination, memory, and aſſociation of ſimilar ideas. *b*, Our education, inſpired by our teachers; which, if it has been eaſy and faithfully taught us, wonderfully aids the rudiments of our underſtanding. *c*, The imitation of others; I would almoſt call it the primary cauſe of this claſs, the real ſource of proper and improper underſtanding.

We are unwilling to ſay more about the ſubject, though highly neceſſary; and indeed ſome of the moſt celebrated philoſophers have already begun to treat very accurately, and have advanced our ideas about it.

licity, ſo they produce different determinations in the *will.* Some of theſe ideas, by which the felicity of our mind is either increaſed or diminiſhed, ariſe merely from the mechaniſm of the perfect body: And amongſt theſe, corporal Pain is a ſorrowful ſenſe or perception in the mind, to which every violence or over-ſtrong ſenſation in any nerve ſeems to ſerve as a foundation; while Pleaſure conſiſts only in the nerves being irritated beyond what is uſual, but in a moderate degree. Itching ſtands related to pleaſure, inaſmuch as both of them have an increaſed flux of blood into the parts in which either the pleaſure or the titillation is perceived; but when increaſed, it tends towards pain, or to an over-violent ſenſe of the nerve. Anguiſh or anxiety is from an over-diſtenſion of the veſſels, becauſe the blood is hindered from paſſing freely through the lungs. The other ideas with which the mind is affected, are either wholly abſtracted from the properties of matter or body, or are at leaſt much leſs ſimple than the foregoing, which ariſe either from ſenſe or mechaniſm. The perception of good ideas excites joy; the deſire of poſſeſſing good excites love, as the expectation of it is the cauſe of hope: on the contrary, preſent evil cauſes ſorrowfulneſs, terror, or deſpair; the deſire of ſhunning evil excites hatred; and the expectation of a future evil excites fear. Hope, curioſity, and glory, ſeem to be affections of the human mind, which neither belong to the body, nor are to be found in beaſts.

DLXV. From theſe affections of the mind, the mere will appears not only to be determined to ſome foreſeen purpoſe, to which it directs the actions of the body, in order to poſſeſs good and avoid evil; but alſo in the body itſelf, unconſulted, and making no great reſiſtance, it exerciſes an equal dominion over the pulſe, reſpiration, appetite, ſtrength, affections of the heart, nerves, and ſtomach; with the changes which ariſe in the other parts, ſerving as ſigns of the paſſions in the mind, from which they immediately follow. Thus anger excites a violent motion of the ſpirits, cauſes a palpitation in the heart, a frequency of the pulſe, a greater ſtrength of the muſcles; urges the blood into the ſmaller pellucid and improper veſſels; and, laſtly, haſtens the expulſion of the bile from its veſſels; by which means it frequently removes obſtructions, or eaſes chronical diſeaſes. Grief, on the contrary, weakens the ſtrength of the nerves, and the action of the heart; retards the motion of the pulſe; deſtroys the appetite and digeſtion; whence it produces a paleneſs, cachexy, diarrhœas, jaundice, ſcirrhoſities of the glands, and other ſlow diſeaſes, ariſing from a ſtagnation of the humours. Thus, alſo, fear ſo much diminiſhes the force of the heart, as to occaſion polypuſes, paleneſs, and weakneſs of the muſcular motions, a palſy or relaxation of the ſphincters, an increaſe of inhalation, but a diminution of perſpiration. Terror from a preſent evil, will alſo increaſe the ſtrength to ſo great a degree, as to cauſe convulſions and a ſtrong pulſe; whence it ſometimes removes obſtructions in palſies, or, by intercepting the courſe of the blood, it kills ſuddenly. Love, hope, and joy, promote the perſpiration, quicken the pulſe, and give the blood a free circulation; whence they increaſe the appetite, and render diſeaſes curable. But exceſſive and ſudden joy often kills, by increaſing the motion of the blood, and exciting a true apoplexy. Shame, after a peculiar manner, retains the blood in the face as if the veins were tied; it will alſo ſuppreſs the menſes or other ſecretions, and in ſome caſes has even produced death.

DLXVI. But in what manner are theſe changes produced, from the commotion of thoſe paſſions in the mind? Do not the nerves cover the veſſels like ſphincter muſcles, ſo as, by contracting them ſuddenly, to increaſe the courſe of the blood, or, by relaxing and weakening their tone, retard and vitiate the circulating juices? That this is the caſe in the ſmaller veſſels, appears evidently from the near ſimilitude of effects from fear and cold upon the nerves of the ſkin. But in the genital parts, from a conſtriction of the veins, under particular circumſtances, we perceive that the blood is manifeſtly collected or accumulated in the parts: and it is no leſs probable, that, even in the larger veſſels, the nervous bridles with which many of them are ſurrounded, produce the ſame effects: for thus, in ſeveral parts, they ſurround and include the meningal, temporal, vertebral, carotid, ſubclavian, cœliac, meſenteric, renal, and other arteries. But after it is ſhown by our experiments, that the nerves are at reſt during the action of the muſcles, nor can be rendered ſhorter by any irritation, we muſt deſert this elegant theory[150]. Nor does it ſeem far from the truth, that the arteries are rendered more or leſs irritable from the various ſenſibility of the nerves, and thus may be contracted more vehemently or languidly by the ſame quantity of blood: and thus the motion of the blood is either quickened or ſlackened, if it is at all certain that the ſmaller arteries have the ſame irritable nature which is common to the large ones. And thus it is that the appetite and periſtaltic motions of the alimentary tube are manifeſtly deſtroyed or depraved by the paſſions of the mind.

DLXVII. Nor is it to be denied, that the Creator has affixed certain characteriſtic marks or evident ſigns to the paſſions of the mind, that in mutual ſociety one man might not impoſe upon another. For the reſpective muſcles, more eſpecially of the voice, face, and eyes, do naturally expreſs the ſeveral paſſions of the mind, ſo faithfully, that they may be even repreſented by a painter. To run through them all would indeed be an elegant theme, but too long for this Compendium. From the actions of theſe muſcles, often repeated by the affections, follow the features or phyſiognomy

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[150] From ſeveral and new anatomical reaſons, I am inclined to embrace the author's former opinion; nor could he himſelf perhaps ever have abandoned it, had not the confuſion ariſing between irritability and ſenſibility, which he dreaded from that aſſertion, determined him to eſpouſe the contrary.

ſiognomy [151] of a perſon's face, which is a perpetual index to the ſtate of the mind, and retains ſomething of the action of the prevailing muſcles; ſo that the appearance of anger often remains in the countenance, after the paſſion itſelf is gone off.

LXVIII. From whence proceeds the conſent of parts, which is ſo famous and often repeated by writers on the practice of phyſic? Some of them appear to depend upon the conjunction or inoſculation of the blood-veſſels; by which the blood being driven out of one, is more ſtrongly urged into another veſſel, which has its branches from the ſame common trunk. To this cauſe belong the revulſions made by blood-letting, the pains of the head which enſue from a cold in the feet, &c. In other parts, the conſent ariſes from a ſimilitude in their fabric, by which they ſuffer like effects from the ſame cauſes in the body: to this alſo we refer the conſent that is betwixt the womb and the breaſts. Another cauſe of this conſent is a continuity of the membranes, extending from one part to another: from hence a ſtone in the bladder excites an itching in the glans of the penis, a diarrhœa cures a deafneſs ariſing from a defluction. Another cauſe of conſent lies in the nerves themſelves, and their anaſtomoſes or communications one with another, as appears plainly from the teeth being ſtupified or ſet on edge by certain ſounds, becauſe the various communications which the hard portion of the auditory makes with the maxillary nerve transfers the diſagreeable ſenſe to the latter. Thus alſo, the ſympathy of the eyes, which is not obſervable in like manner in the ears, proceeds from the mutual conjunction of the optic nerves within the ſkull; and thus a ſtone in the kidney excites vomiting. Laſtly, the conſent may proceed from ſome cauſe acting on the common ſenſory, and beginning of the nerves; whence the irritation of a ſingle nerve manifeſtly excites ample convulſions, ſpreading through the other parts: ſo an univerſal epilepſy will proceed from a local diſorder, &c. A conſent is obſerved, in ſome diſeaſes, from a tranſlation of the matter of a diſeaſe by filtration through the cellular ſubſtance of one part to another; and another kind proceeds from the incumbent weight or actions of the adjacent muſcles and arteries.

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[151] It is a dangerous, and too deceiving ſtep, to give a deciſion from a reliance on the phyſiognomy. I reckon Camper the beſt judge of this ſubject, who ſhould be conſulted for his ingenious remarks. He muſt underſtand the rules of art, the good and bad diſpoſition of men, the characters of nations and the genius of brutes, who wiſhes to write with any ſort of authority upon the ſubject. However, there is in the muſcles of the face a certain declaration, given by the words and ſigns, of a good or bad ſtate of mind, which never will deceive a ſkilful perſon; but may be wonderfully diſguiſed by thoſe addicted to lying. *Fronti nulla fides, nimiumque ne crede colori.*

DLXIX. But there is ſtill another remarkable conſent to be explained betwixt the body and the mind. For that the nature of the mind is different from that of the body, appears from numberleſs obſervations; more eſpecially from thoſe abſtract ideas and affections of the mind which have no correſpondence with the organs of ſenſe. For what is the colour of pride? or what the magnitude of envy or curioſity? to which laſt there is nothing ſimilar in brute animals; neither can that happineſs which is deſired by it, *viz.* the glory of new ideas, be referred as an acquiſition to any corporeal pleaſure. For is it poſſible, that a body can acquire two kinds of forces by the uniting of an infinite number of ſmaller parts into one maſs; each of which ſhall not only preſerve their own particular properties and affections, and repreſent themſelves, but alſo join together into one conſcious whole, differing from all the characteriſtics of its component parts, and yet be capable both of perceiving and comparing the attributes of thoſe parts? Is there any one inſtance of a body, which, without an external cauſe, can, like the mind, paſs of itſelf from reſt to motion; or is there any body that can change the direction of its motion, without the action of ſome other cauſe? Upon ſlight reflection, it will be obvious to all, that voluntary action is the attribute of the mind alone.

DLXX. Yet the mind, however different from the nature of the body, is cloſely tied to the ſame, under certain conditions; ſo that ſhe is obliged to think upon thoſe ſpecies which the body offers to her perception; and again, ſo that ſhe cannot perceive, remember, nor judge, without the repreſentation of thoſe corporeal ſpecies, which are lodged in the brain: and again, her will is the cauſe of the greateſt and ſwifteſt motions in the body.

DLXXI. Thoſe have behaved modeſtly who, confeſſing themſelves ignorant as to the manner in which the body and mind are united, have contented themſelves with proceeding no farther than the known laws which the Creator himſelf has preſcribed, without inventing and ſupplying us with conjectures not ſupported by experience. We may, ſurely, be excuſed in this reſpect from the obſervation (DLVI.), which is here equally certain as in optics, that the affections of bodies cohere, by an arbitrary relation or connection, with the thoughts of the mind; in ſuch a manner, that they would produce thoughts of a different kind, if the Creator was to alter the figure, the refracting power, or colours of the parts of the eye. Thus he has eſtabliſhed a law, which obtains always, betwixt the leaſt refrangible rays and a red colour, or an idea of ſuch in the mind: and thus there is a law betwixt the impreſſion of thoſe rays upon the retina, and the connection with the correſponding thought. Nor need we be more aſhamed to confeſs our ignorance in the mechaniſm of this law in the effects of nature, than we are to own ourſelves unacquainted with the nature of the former.

DLXXII. But it will perhaps be demanded of us, Whether the mind does not govern the whole body? and whether or no all the motions and actions in the body do not ariſe from the mind, as the immediate ſpring and principle of motion? Whether even the motion of the heart, arteries, and reſpiration, does not ariſe from the mind, conſcious, and ſolicitous for the common good of the whole ſyſtem? Whether this power of the mind does not appear in the ſtopping of hemorrhagies from wounds, by grumous concretions; to which add, the force of paſſions of the mind, and the power of the mother's imagination, in the marking or other blemiſhes of infants? Whether the abſence of conſciouſneſs in the mind, with reſpect to theſe defects, be not excuſable, from the known obſcurity of attention which ſhe gives to the reſpiration, the motion of the eye-lids, and muſcles of the eye itſelf, the ear, or tongue; all which motions, we know, are effected by the will, although we know not the organs, nor take any notice of the action of the will, when we breathe, look, hear, or even walk, while we are taken up with other thoughts? Whether or no is it certain, that all bodily motions ariſe from the mind, on the account of our being unable to find out any other cauſe, conſtantly united to the body, to which we can manifeſtly refer them?

DLXXIII. There are indeed many reaſons which will not permit us to conſent to this opinion And, firſt, the conſtruction and government of the body itſelf appear greatly to exceed all the power and wiſdom of the mind. The mind is able to ſee but one point diſtinctly at a time (DLV.), and it can entertain only one thought or idea at once: for if it endeavours to ſee two objects at a time, to contemplate two different ideas together, or read two letters at once, the ſenſe of both is immediately confuſed, the mind ſtrays in her reaſoning, and makes no right judgment of either object; inſomuch, that being ſenſible of this her weakneſs, whenever ſhe endeavours to make a ſerious and diligent inquiry into any object or intended work, ſhe withdraws herſelf, and ſhuts up all the ports of ſenſe, without taking any impreſſions either by the ſight, hearing, ſmelling, &c. or without exerciſing any of the voluntary motions of the muſcles. But the mind ought to be capable, not only of infinite thoughts, but alſo diſtinct ones, ſo as to be able to perform and govern ſo many hundred muſcles, organs, veſſels, and moving fibres, in ſuch a variety of ways, and with ſo great an exactneſs, as is difficult to, or even above all the ſolutions that can be given by the working of geometrical problems: and yet, by this hypotheſis, the mind, ignorant both of herſelf and of her works, ought not only to be equal to ſo immenſe a taſk; but likewiſe, at the ſame time, ſhe muſt, over and above thoſe works, be capable of contemplating the moſt difficult and abſtracted ideas, without either diſturbing her meditations by the cares which concern the body, or neglecting any of her neceſſary corporeal offices by the variety of her mental operations.

DLXXIV. Moreover, if, without being conſcious of our will, we are nevertheleſs able, by that faculty, to influence the reſpiration, the winking of the eyes, &c. and even to be able not only to govern, but alſo to ſuſpend our breathing, ſhut or cloſe our eyes, and open them again; it follows from thence, that we never loſe either the conſciouſneſs or the uſe of thoſe actions, and conſequently neither the government of them. But we are able to perform nothing of this kind in the heart or inteſtines; we cannot reſtrain the motion of thoſe parts when they are too quick, nor excite them when they are too languid. In ſuch a number of perſons as inhabit the world, why do we not meet with ſome who can govern the motion of their guts? Or why, in all the ages of the world, not one who could govern the contractions of the heart? If cuſtom only is the cauſe of this unknown power, why does not the mind receive a ſenſe of her action, in moving the heart, after it has ſtood ſtill for whole hours, or even days, in ſwoons, in hyſteric fits, and in perſons drowned?

DLXXV. But it is evidently a falſe poſition, that all the motions of the body ariſe from the mind, without which the body would be an immoveable unactive maſs: for the force of muſcular contraction, by any kind of ſtimulus, to which the motion of the heart, inteſtines, and perhaps all the other motions in the human body are obedient (CCCCXCI.), does nor require the preſence of the mind; ſince that power continues a conſiderable time in a dead body, and may be recalled again into action by mechanical cauſes, as heat, inflation, &c. Nor does this power deſert the fibres ſo long as they continue unſtiffened by cold, although the mind may have been a long time ſeparated from the body by a deſtruction of the brain: and this action we ſee more evidently in the heart, after that muſcle has been taken out of the body for ſome time, ſo as to be ſeparated from any imaginable connection with the mind.

DLXXVI. As to the blemiſhes of infants, we have declared in another place, how little that article is to be depended on. The adminiſtration of the vital motions, in diſeaſes, is not under the rule of any prudence, but governed almoſt entirely by the power of ſtimulus; as we are manifeſtly taught from the moſt ancient and only certain practice, by which we are directed to reſtrain the too great violence of theſe motions in acute and intermitting febrile diſeaſes, by the uſe of blood-letting, with the poppy, nitre, Peruvian bark, &c. The wiſeſt philoſopher in the world has no more privilege or advantage in the government of his body, than the mereſt idiot; and that a fœtus, when it is born, has not ſufficient knowledge how to move its muſcles, but by experience learns to go, prattle, ſee, and, finally, to rear up its own body, which is formed with incredible art, is indeed an aſſertion ſo void of probability, as is ſufficient to refute the hypotheſis.

DLXXVII. A ready diſpoſition to the exerciſe of ſenſe and voluntary motion, in healthy organs, is called *vigilance* or *wakefulneſs;* but an indiſpoſition to ſuch an exerciſe of them, with an inclination to reſt, in all the ſaid organs, while they remain healthy and entire, is called *ſleep.*

DLXXVIII. In ſleep, the mind either thinks not at all of what ſhe knows or retains in memory; or elſe ſhe only attends to the traces of paſt objects repoſited in the common ſenſory (DLVIII.); the vivid repreſentations of which excite altogether the ſame perceptions as are made by the impreſſion of external objects upon the organs of ſenſe, by which they were firſt received. Theſe repreſentations of ſpecies to the mind are called *dreams;* and happen whenever a ſmall portion of the brain or common ſenſory is, by the refluent motion of the ſpirits, kept in a ſtate of vigilance, while all the reſt of the empire of ſenſe and voluntary motion is ſilent and at reſt. Sometimes there are certain voluntary motions, following of courſe from the perceptions thus perceived by the mind, ſuch as ſpeech, or motion of all or ſome of the limbs, conformable to the nature of what the mind perceives; and hence ſome walk in their ſleep.

DLXXIX. But, during the time of ſleep, the motion of the heart, with the diſtribution and circulation of all the other humours in the body, are regularly continued, together with the periſtaltic one of the ſtomach and inteſtines; and, finally, the action of the ſpincter muſcles, with the reſpiration, are continued in a like manner. This compoſition, in which a certain number of the organs are at reſt, while others continue their motions, renders a knowledge of the mechanical cauſe of ſleep ſomewhat difficult to attain.

DLXXX. Therefore, in order to make this diſcovery, with all its cauſes, we ſhall conſider all the appearances both of ſleep and vigilance, and trace them in all kinds of animals; for that condition which appears conſtantly to follow from all thoſe cauſes and appearances, will be the true and mechanical cauſe of ſleep. Sleep naturally follows after the vigilance and labour which are joined to human life. For when a perſon is awake, there is a continual motion or exerciſe of the voluntary muſcles, of the parts which guard the ſenſes, and of the affections of the mind; all which continually add a new ſtimulus to the nerves, blood-veſſels, and heart itſelf. Thus the blood, by continual motion and triture, changes its ſmooth albuminous nature, to a rough alkaline, and in ſome degree putrid, ſharpneſs; while, at the ſame time, its more fluid parts, eſpecially thoſe ſubtile ones which compoſe the nervous ſpirits, are diſſipated faſter than they are ſecreted; whence gradually enſues both a weakneſs and a wearineſs of the body: and, if the vigilance be continued longer than uſual, there is alſo a feveriſh heat, a greater acrimony of the humours, and a ſenſible loſs of ſtrength. As the night advances, a weight or heavineſs ſeizes all the large muſcles and their tendons, the mind becomes unfit for any accurrate thought or ſtudy, and ſeeks after reſt. Hereupon the powers which hold the body erect, ſhrink from their office, the eye-lids cloſe, the lower jaw falls down, a neceſſity of yawning comes on, the head nods forward, and by degrees we take leſs notice of the external objects, till at length all the thoughts and ideas are in confuſion, and a ſort of delirium enſues; from whence there is a tranſition to ſleep not ſufficiently marked, which however always precedes ſleep. In this natural ſleep, which is common to all animals, the cauſe ſeems to be a deficiency of the nervous ſpirits, which have been every where largely conſumed by the exerciſes of the muſcles and ſenſes, in whoſe actions there is probably a great quantity of this fluid exhaled.

DXXXI. A perfect reſt or compoſure of the mind and external ſenſes, with the abſence of all ſtimulus or irritation in the head and other parts of the body, joined with darkneſs, promote and haſten the forementioned ſteps of ſleep, and render it more quiet or profound.

DLXXXII. Again, it is obſervable, that a variety of cauſes, which weaken the powers, incline to and increaſe ſleep; ſuch as great loſſes of blood from any cauſe, bleeding from a vein, the uſe of cooling medicines or thoſe prepared from the poppy, and cold of the external air; to which add, ſuch as call off the quantity of blood flowing to the head, as warm-bathing of the feet, a plentiful ingeſtion of food into the ſtomach, which is found to produce ſleep in all kinds of animals.

DLVIII. On the contrary, again, there are various hot medicines which induce ſleep, by exciting a greater afflux of blood to the brain; ſuch as wine, alcohol, or vinous ſpirits of all ſorts, but more eſpecially when reſolved into vapour; opium, hyoſcyamus, the indigeſtible particles of our aliments; to which add, acute and malignant fevers of various kinds, or elſe ſuch things as retard the return of the venous blood, as fatneſs. All theſe cauſes ſeem to concur in this, that the blood being collected in the head, compreſſes the brain, ſo as, in a degree, to intercept the courſe of the ſpirits from thence into the nerves.

DLXXXIV. But likewiſe mechanical cauſes produce a ſleepineſs; namely, a compreſſure of the dura mater and brain, whether from extravaſated blood, a depreſſed part of ſome bone, or a collection of ſerous water [redacted] ventricles of the brain itſelf.

DLXXXV. Sleep, therefore, ariſes either from a ſimple deficiency of the quantity and mobility of the ſpirits, or a compreſſure of the nerves; but always from a more [redacted] motion of the ſpirits through the brain.

DLXXXVI. [redacted] likewiſe confirmed by the cauſes of vigilance: for all thoſe things prevent ſleep which produce plenty of ſpirits; more eſpecially warm aromatic drinks, which ſend plenty of minute ſtimulating particles to the head, by which the motion or courſe of the blood is moderately quickened through the brain; and, being at the ſame time more dilated, makes a larger ſecretion of ſpirits in a given time.

DLXXXVII. Sleep, again, is hindered by cares of the mind, meditation, ſtudy, and paſſions of a ſtronger degree, with pains of the body and mind; all which hinder the ſpirits from reſting in the common ſenſory, or urge them ſo as to prevent the nerves from collapſing. Therefore, as the former increaſe the quantity of the ſpirits, theſe cauſes increaſe their motion. And therefore, again, the ſame concluſions are to be made from hence as before (DLXXXV.); namely, that the nature of ſleep lies in a collapſing of the nerves which go out from the common ſenſory.

DLXXXVIII. If it be inquired, Whether the ſeat of ſleep be not in the ventricles of the brain? we anſwer, that it is not conſiſtent with the ample bounds or dominions of ſleep, which extends itſelf even to ſuch animals as have no ventricles in the brain. Whether do the vital actions continue to be carried on in ſleep, as it is only an affection of the brain independent of the cerebellum? and what may be the cauſe of this difference, by which the animal offices reſt in ſleep, while the vital operations are continued? We know not of any other reaſons, beſides thoſe before given, that the vital motions are perpetually ſtimulated into action, from the cauſes urging a neceſſity of keeping them from reſt (CCCXCII.)

DLXXXIX. The effect of ſleep is a moderation or abatement of all the motions in the human body. For now the action of the heart only remains, by which all the humours are ſent through the veſſels, at the ſame time that all the muſcles and perception of the nerves, with the paſſions of the mind and voluntary motions, are diſcontinued; by which, independently of the heart, the courſe of the ſpirits was quickened, ſo as to cauſe wakefulneſs (DLXV. CCCCXVII.) Thus the heart, is gradually reſtored from its quick and almoſt feveriſh pulſation, to the ſlow and calm condition in which we find it in the morning; the breathing in ſleep becomes ſlower and ſmaller, the periſtaltic motion of the ſtomach and inteſtines, the digeſtion of the aliments, the ſenſe of hunger, and the progreſſion of the fæces, are all diminiſhed; at the ſame time, the thinner juices move more ſlowly on, while the more groſs and ſluggiſh are collected together, and the fat being poured out is accumulated in the cellular ſubſtance; the viſcid albuminous humour, for the nouriſhment of parts, adheres more plentifully to all ſides of the fibres and ſmall veſſels; the conſumption of the ſpirits, the attrition of the blood, and the quantity of perſpiration, are all diminiſhed. Thus, while the quantity of the nervous ſpirits continues to be ſecreted, with a leſs conſumption, it is by degrees accumulated in the brain, ſo as to diſtend and fill the collapſed nerves, that, both in the internal and external organs, return to action by the approach of ſome ſmall ſtimulus, by which they are reſtored to vigilance. Sleep, continued for too great a length of time, diſpoſes to all the diſorders that attend a ſlow circulation, to fatneſs, drowſineſs, weakneſs, and cachexies; and is, at the ſame time, highly detrimental to the memory.

DXC. From whence does yawning attend thoſe that are about to go to ſleep? We anſwer, To promote the paſſage of the blood through the lungs, which is now ſlower. Whence the ſtretching of the limbs? To increaſe the motion of the ſpirits, that they may overbalance the natural contraction of the muſcles, by which all the limbs are drawn into a moderate degree of contraction. If it be demanded, From whence came the unjuſt opinion, which has been ſo well received, that the motion of the heart becomes ſtronger in ſleep, and the perſpiration more plentiful? we anſwer, That the miſtake aroſe from the increaſed heat ariſing from the bed-cloaths, by which the perſpirable matter being confined, every where conduces to warm, ſoften, and relax the ſkin. But any one that ſleeps in his uſual garments grows colder; and animals which ſleep for a long ſeaſon together grow cold externally to the higheſt degree, as field-mice and hedge-hogs. From whence is it that all animals grow ſleepy after taking food? Not from a compreſſure of the aorta, or from a repletion of the head with blood; for even animals which have ſcarce any brain ſleep after food. Whether or not do the indigeſtible particles of our aliments, by paſſing leſs eaſily through the brain, and compreſſing its medulla, produce ſleep of a leſs benign kind? Whether or not is there a perpetual dreaming, ſo as to be inſeparable from ſleep? and whether this be natural, ſo that the mind never ceaſes to be without thought, as a conſequence [illegible] by R. Parkland

ſequence following from ſenſation? We anſwer, This does not ſeem to be the true ſtate of nature; for dreams we judge to be rather referable to diſeaſe, or to ſome ſtimulating cauſe that interrupts the perfect reſt of the ſenſorium. Hence that ſleep refreſhes moſt in which there are no dreams, or at leaſt that in which we have no remembrance of any. Hence they are generally wanting in the firſt ſleep, at which time the ſpirits are moſt exhauſted, and return in the morning when theſe are in ſome meaſure repaired. Hence we ſee, that intenſe cares of the mind, or the ſtrong impreſſion of ſome violent idea received in the memory, hard indigeſtible food abounding in its quantity, with any uneaſy poſture of the body, are the moſt uſual cauſes that excite dreams; for they are uſually generated by ſome ſenſation which, by the law of aſſociation of ideas, joins with itſelf a whole collection of ſpecies having an affinity with that one.

CHAP. XIX.

Of Mastication, Saliva, *and* Deglutition.

DXCI. SUCH hard and tough foods as conſiſt of long parallel fibres, or are covered with a bony ſhell or cartilaginous ſkin, generally require maſtication, to divide them into leſs cohering parts, that they may more eaſily yield their nouriſhment to the diſſolving powers of the ſtomach. The more diligently they are ſubdivided in the mouth, the more reliſhing and agreeable they become to the ſtomach; the nearer they approach to the nature of a fluid, and the more eaſily are they digeſted or aſſimilated.

DXCII. Therefore moſt animals are provided with teeth, extremely hard, with a root that is indeed bony and hollow; ſince it receives, through a ſmall hole in the tip or point of each fang, little blood-veſſels, and a nerve, which go to form its internal perioſteum [152]:

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[152] There is no part of our body we are better acquainted with than

and this whole root, being fixed into a ſocket of the jaw conformable to itſelf, is, in the upper part towards its crown, ſtrongly ſurrounded and tied down by the adhering gum. But the crown, or upper part of the tooth, placed above the gums, is not bony; but a peculiar ſort of enamel, of a harder, denſer ſubſtance, and almoſt of a glaſſy texture, compoſed of ſtraight fibres vertical with its root, and running together towards the middle. This laſt portion of the tooth, having neither perioſteum nor veſſels, perpetually grinds away, and is as often repaired again by a kind of petrifying juice, that aſcends or filtres from the cells of the root; by which mechaniſm they are therefore ſupplied with a great degree of hardneſs, very fit to overcome that of other bodies, and to grind the food with their unequal ſurfaces.

DXCIII. As the materials of our food are various in their texture and firmneſs, nature has accordingly made our teeth variouſly figured. In us, the anterior or inciſive teeth are four in each jaw, weaker than the reſt, and fixed by a ſingle root, upon which ſtands a crown

than the teeth, both with regard to their riſe, ſtructure, and changes, and their diverſity in different animals, uſe, and diſeaſes. A few remarks remain, which have eſcaped the induſtry of Janck, Albinus, and the celebrated Hunter, and which future experience may ſuggeſt. I ſhall add a few. The teeth which firſt appear; I mean the four inciſores of both jaws, the two canini and the four molares, lie hid in a canal or capſule, ſupplied with an artery and vein: theſe run the whole length of the canal; in the lower jaw below the teeth, in the upper above them; and every tooth ſends off as many branches as it has roots. All theſe veſſels are diſtributed through a membrane which encompaſſes the ſhooting tooth. The veſſels retain the ſame trunk; although, the tooth being ſenſibly formed, the prolonged root at length leaves a ſmall hole, which the plexus of the tooth's artery, vein, and nerve enters. Any tooth which is about to come out is incloſed in its own membranous ſack, elegantly ſet with veſſels; which net-work, in my preparations, I cannot but admire, forming its internal and external perioſteum. The moſt tender nervous filaments enter the ſame ſac with the veſſels, and terminate in the cellular ſubſtance, leaving no viſible proof that the nerves are intermixed with the oſſeous ſubſtance.

crown inwardly concave, outwardly convex, and terminated by a gradual extenuation, like a wedge or chiſel, with a rectilineal edge. The office of theſe is only, in the ſofter foods, to cut thoſe which are tougher than the reſt into ſmaller portions; ſuch as the fibres and membranes of animals and vegetables, with the brittle ſeeds and kernels of fruits.

DXCIV. The ſecond ſpecies is the *canine teeth*, which are two only in each jaw, fixed by a longer and ſtronger, but ſingle root; from whence their crown is extenuaated into a cone. Theſe lacerate tough aliments, and hold faſt ſuch as require a longer triture by the grinders.

DXCV. The third order of the teeth is that of the *molares*, which in general are compoſed of ſeveral roots, with a quadrangular crown, ſomewhat flat ſurfaced, but more or leſs divided by rocky aſperities. The two foremoſt of theſe are weaker than the reſt, inſerted by two, or often but one root, with the ſurface of their crown parted into two; but the three poſterior grinders are larger, fixed by three, four, and ſometimes five roots, but terminated in their crown by only one ſurface, ſomewhat ſquare and flat, but leſs in the lower than upper jaw, and is ſubdivided into a number of eminences correſponding to that of their roots. Betwixt theſe teeth, the moſt compact or bony foods are interpoſed and broke, as the more tough and hard are ground ſmaller, while the lower teeth are urged obliquely and laterally againſt the moveable upper ones; and theſe are the teeth which perform principally what we are to expect from maſtication of food.

DXCVI. That the teeth might break or grind the food with due ſtrength and firmneſs, the uppermoſt are fixed into the ſockets of the immoveable upper jaw, as the lower ones are into the lower moveable jaw, which is a ſingle bone, and ſo joined with the temporals, that it may be drawn down from the upper jaws, and pulled up againſt them with a great force; and may be moved laterally to the right or left, forward and backward. Thoſe various motions of the lower jaw depend upon the articulation of its oval heads, in which the lateral parts of the jaw terminate, convex or higheſt in the middle, and received betwixt the oblique protuberances of the temporal bones, in a ſhallow excavation, at the root of the jugal proceſs, deeper in its middle; and increaſed by a little excavation of the ſame kind before the auditory paſſage, from which it is ſeparated by a peculiar fiſſure. This joint has the freer liberty in moving, and its incruſtated cartilages have a longer duration, by the interpoſition of a ſmall cartilaginous plate, betwixt the condyle of the jaw and tubercle of the temporal bone; concave in its middle above and below, with riſing ſides, which ſurround the tubercle of the temporal bone upward, the condyle of the jaw downward, and correſponds to the adjacent inequalities.

DXCVII. The muſcles moving the lower jaw, which are weak in man, but very ſtrong in brute animals, are the *temporalis* and elevator, ariſing from a large part of the ſide of the ſkull, and from the outward tendinous expanſion of it the ſtellated fibres run together into a tendon fixed to the ſharp proceſs of the jaw; the *maſſeter* elevator, having two or three diſtinct parts or leſs muſcles, deſcends from the os jugalis and margin of the upper jaw backward into the angle of the lower jaw. Both theſe act in concert; but the temporal muſcle brings the jaw more backwards, and the maſſeter forwards. The *pterygoideus internus* deſcends from the pterygoide foſſa, and from the palate bone and root of the little pterygoidal hook, with the internal wing, into the angle of the lower jaw, which it elevates or draws to one ſide or the other alternately. The *pterygoideus externus* has a double origin; one tranſverſe from the inner wing and adjacent bone of the palate, with the poſterior convexity of the upper jaw: the other, deſcending, ariſes from the hollow temporal part of the great wing of the ſphenoides; thence it proceeds backward and downward into the outer part of the condyle of the lower jaw, which it moves laterally, and draws forward before the upper jaw.

DXCVIII. The lower jaw is depreſſed, ſo as to open the mouth by the digaſtric or *biventer* muſcle, ariſing from an hollow of the maxillary bone; from whence deſcending, its middle tendon is tied by a firm cellular ſubſtance of a tendinous nature to the os hyoides; and being likewiſe connected to the mylohyoideus, and then paſſing through the divided fibres of the ſtylohyoideus, it is increaſed by another fleſhy belly, inſerted at the ſymphyſis of the two halves of the lower jaw, within the chin. Moreover, the mouth may be partly opened by all the other lower muſcles of the jaw, os hyoides, and the larynx, as the geniohyoideus, genioglоſſus, ſternohyoideus, ſternothyroideus, coracohyoideus, and latiſſimus colli; although the latter rather draws the ſkin of the neck and face downward than the jaw itſelf. The geniohyoideus and digaſtric muſcles have a power of drawing the jaw backwards.

DXCIX. The lower jaw is elevated with a great force, ſo as to divide the food by the preſſure of the upper and lower teeth againſt each other, by the action of the temporal maſſeter, and internal pterygoide muſcles; the contraction of which appears by experiments to be very powerful, and ſufficient to raiſe ſeveral hundred weight. The lateral and circular motions of the jaw upon one of its immoveable condyles are performed by the external and internal pterygoidei, acting either alone or together with the former. Thus the food is cut, lacerated, and ground to pieces; and if the maſtication be continued diligently, it is together with the liquors of the mouth, reduced into a kind of pulp.

DC. The fore-part of the teeth is covered with a cutaneous and fleſhy ſack, which is every where produced from the integuments of the face; and makes a hollow, in which both rows of teeth are ſhut up. The ſides are called the *cheeks*, the middle parts the *lips*. From this cavity there lies a paſſage, betwixt the teeth, into the mouth; which on the upper part is bounded by the bony and ſoft palate, underneath by the fleſhy parts lying under the tongue, and on the fore-part by the teeth. On the back part it opens between the ſoft palate and tongue into the fauces. The tongue divides the cavity of the mouth in the middle, and is eaſily moveable to every part of it.

DCI. During the trituration of the food in the mouth, there is continually poured into it a large quantity of a watery clear liquor, evaporable or inſipid, or at leaſt but very little ſaline, and containing but little earth; neither acid nor alkaline, although from thence may be obtained a very ſmall portion of lixivial ſalt; of which there are numerous ſprings in the neighbourhood. A large quantity of this *ſaliva* is ſeparated by numberleſs ſmall glandules of the lips and cheeks, of an oval figure, and ſome larger ones which are placed round the mouth of the duct of the parotid gland; and laſtly, the pores of the hard palate pour out this liquor, which they ſecrete, through a little ſhort duct and hole. The juice poured out from the exhaling veſſels of the tongue, mouth, and cheeks, is of the like kind, or rather more watery. As for the ductus inciſivus, we are now ſufficiently certain that it is blind, or diſcharges nothing into the mouth, only gives paſſage to an artery from that of the palate into the nares.

DCII. The ſaliva is a watery liquor, with a moderate quantity of ſalt, partly lixivial, and partly culinary; with ſome oil and earth, diſſipable by the fire; with ſcarce any taſte, unleſs given to it by diſeaſe or famine, The quantity produced is very conſiderable, as twelve ounces have been known to flow out from wounds in thoſe parts in the ſpace of an hour. By good-mannered people it is for the moſt part ſwallowed; and uſefully, as it cannot be thrown away without hurting the digeſtion.

DCIII. But the ſalival glands eſpecially ſupply the watery humour called after their own name. Of theſe the principal is the parotid, filling up a large interval betwixt the auditory paſſage and the lower jaw, to which it is immediately contiguous in the part uncovered and to the maſſeter. It is a conglomerate gland, made up of round or grape-like cluſters, connected by the cellular ſubſtance; which laſt, being denſified and reticulated, forms an almoſt tendinous covering that ſurrounds and connects the whole gland. Its duct is white, vaſcular, and capacious, aſcending from the bottom of the gland to the os jugale, from whence it is tranſverſely inclined, and takes in by the way a ſmall duct of a ſolitary glandule on the top of the maſſeter, or elſe lodged diſtinct, or continued upon the parotid itſelf, and is rarely double; after this the duct, bending round the convex edge of the maſſeter, opens with an oblique or cut aperture, without a papilla, through the departing fibres of the buccinator muſcle, in the midſt of many little glandules of the cheek. The bulk of this gland, and the number of its arteries, make it the chief ſpring from whence the ſaliva flows.

DCIV. Another ſmall gland, adjacent to the parotid, but twice as little, compoſed of ſofter and larger kernels, connected by the like cellular membrane, is, from its ſituation at the lower angle of the jaw, called *maxillary;* being in part terminated only by the ſkin, but in part ſends off an apendix over the mylo-hyoide muſcle; which, following the long hollow ſide of the lower jaw, of a granular fabric, is ſpread under the membrane of the mouth, by the name of *ſublingualis.* From the larger maxillary, together with this appendix, a duct paſſes out, which, being a long way covered in its middle part by the ſublingualis, receives one, two, or three branches; by whoſe inſertion being increaſed, it opens into a projecting membranous cylinder under the bridle of the tongue. But other ſmall and ſhort ducts from the ſublingual gland, from the number of three, four, or more, to twenty, with ſhort little ducts and points in the line continued backwards from the ſmall frenum, perforate the edge of the tongue, and ſecrete ſaliva. There are ſome inſtances where the larger anterior branch of the duct of the appendix, which uſually joins itſelf to the maxillary gland, goes on ſingle, parallel, and opens by itſelf. Other glands alſo, ſimilar to thoſe of the cheeks, which likewiſe may be reckoned among the ſublingual ones, by their proper ducts perforate the membrane of the mouth where it departs from the tongue. Various other ſalival ducts have been publiſhed by different profeſſors, which are not confirmed by anatomy.

DCV. The Creator has wiſely provided, that, by the motion of the jaw in maſtication, the ſalival glands ſhall be compreſſed by perfect neceſſity, ſo as to diſcharge their juices into the mouth in greater plenty. For, when the mouth is opened, the maxillary gland, being preſſed by the digaſtric and mylo-hyoideus, throws forth a fountain of ſaliva; the maſſeter when ſwelled preſſes the parotid gland, as does alſo the cutaneous muſcle of the neck which lies over it: and it is this muſcular preſſure that excites the appetite, and pours the ſaliva into the mouth.

DCVI. The food therefore, being in this manner ground betwixt the teeth, and intermixed with the watery ſaliva and air, is broken down into a ſoft juicy pulp, pliable into any figure, and replete with elaſtic air, which by the action of the latter undergoes a farther diſſolution, by the warmth of the parts exciting the elaſticity of the air to expand and burſt aſunder the confining particles of the food, betwixt which it is included. In this act of maſtication, the oily, aqueous and ſaline parts of the food are intermixed the one with the other; the ſmell and taſte of different ingredients are loſt in one, which by the dilution of the ſaline parts with ſaliva renders the food flavourable: but ſuch particles as are more volatile and penetrating, being directly abſorbed by the bibulous veſſels of the tongue and cheeks, enter ſtraight into the blood-veſſels and nerves, ſo as to cauſe an immediate recruit of the faculties.

DCVII. But the motions which are neceſſary for turning round the food, applying it to the teeth, and conveying it through the different parts of the mouth in maſtication, are adminiſtered by the tongue, cheeks, and lips. And firſt, the tongue being expanded ſo as to form a ſmall concavity in in its back or ſurface, takes up the food thus prepared, and conveys the charge by its moving powers (CCCCL.) to the parts for which it is deſigned. At one time the tongue, rendered narrow by lateral contraction, ſearches every part of the mouth with its tip, and turns out the latent food into a heap on its common concavity. At another time, applying its extremity to the fore-teeth, and raiſing itſelf up ſucceſſively, it draws from the cavity of the mouth the fluids or chewed aliments, and conveys them to the fauces or back part of the mouth behind the teeth.

DCVIII. But theſe motions of the tongue are likewiſe governed by the muſcles and membranes, largely inſerted into the os hyoides, the baſis of which is internally concave; from whence are extended horns laterally and outwards, terminated by more protuberant heads, and completed with little oval cornices; and this bone being drawn down by its reſpective muſcles, depreſſes the tongue at the ſame time, and the lower jaw likewiſe, if the muſcles of that be relaxed. Theſe powers are the *ſternohyoideus*, but ariſing alſo in part from the clavicle, extenuated upwards, and ſtriped with tendinous lines; the *ſternothyroideus*, ariſing as the former, and broader from the upper rib; which muſcle, depreſſing the cartilage to which it is inſerted, is under a neceſſity of pulling down the *os hyoides*, to which it is joined: this is partly intermixed with the hyothyroideus and thyreo-pharyngeus, and every where confuſed with the ſternohyoideus. Next the coracohyoideus, ariſing from the upper and ſhorter ſide of the ſcapula, near its notch, aſcends obliquely, and at the croſſing the jugular vein changes into a tendon; from whence the other belly of the muſcle aſcends direct to its inſertion into the os hyoides, which it depreſſes, being every where confounded with the ſternohyoideus. The *hyothyroideus* is determined by the former muſcles.

DCIX. The other powers which elevate the os hyoides, together with the tongue, are its *ſtyloglоſſus* muſcle, ſuſtained by a peculiar ligament of the upper jaw. The *ſtylohyoideus*, a weak muſcle, often ſplit for paſſage of the biventer, and again united into one portion, after adhering to the tendinous expanſion of the biventer, is inſerted, together with its fellow, into the angle of the baſis, and often into the horn of the os hyoides: the ſecond ſtylohyoideus, when it is preſent, reſembles the former, behind which it is placed; ariſing from the tip of the ſtyloide proceſs, it is inſerted into the ſmall oſſa triticea, and anſwers the purpoſe of a ligament to ſuſtain the os hyoides. All theſe muſcles draw the tongue back, but laterally they elevate it. The *mylohyoideus*, ariſing from the whole length of the jaw, running into one with its companion, elevates the tongue, and fixes it in making various motions, or in like manner depreſſes the jaw. The *geniohyoideus*, being a companion of the genioglоſſus, pulls the tongue forward out of the mouth.

DCX. But, moreover, the muſcles of the cheeks variouſly move and preſs the food in the mouth. Others move it from the cavity of the cheeks into the inner cavity of the mouth behind the teeth, as we ſee in the buccinator when the mouth is ſhut. Others open the mouth for receiving the food; ſuch as the double-headed proper elevator of the upper lip, and the elevator which is partly common; to which add, the zygomaticus, upper and lower; the riſorius, triangularis menti, and the depreſſor proper to the angle of the mouth; which ariſing from an excavation on each ſide, near the ſocket of the canine tooth, are inſerted into the orbicularis of the lips, Others, again, cloſe the lips, that the food received may not return out of the mouth; ſuch as the orbicularis of each lip, the proper depreſſor of the upper lip, and the proper elevator of the lower lip, and that which ſerves in common for the elevation of both.

Of theſe, more particular deſcriptions may be had from profeſſed ſyſtems of anatomy.

DCXI. By theſe means the food, ground and mixed with the ſaliva into a ſoft pulp, collected from all parts of the mouth by the tongue into the arched ſpace betwixt the teeth, is afterward, by the expanſion and ſucceſſive preſſure of the tongue, conveyed backward behind the teeth; and, in this action, the tongue is expanded by the ceratogloſſi and genioglosſi, and rendered a little concave by the ſtylogloſſus. And from thence it is next conveyed into the fauces.

DCXII. For the tongue being raiſed by the ſtylogloſſi, and broadly applied to the palate, firſt by its apex, then alſo inſenſibly by its poſterior extremity, preſſes the food ſucceſſively towards the fauces, which at that time only afford an open paſſage. After this, the thick root and back part of the tongue itſelf, by the forementioned muſcles, and by the ſtylohyoidei and biventers carried backward, preſſes down the epiglottis, which ſtands up behind the tongue, connected therewith by numerous membranes, and perhaps by ſome muſcular fibres. At the ſame time, the muſcles elevating the pharynx all act together; ſuch as the biventer, geniohyoides, geniogloſſus, ſtylohyoideus, ſtylogloſſus, ſtylopharyngeus, and the other elevators, which now draw the larynx upward and forward, that the epiglottis, being brought nearer to the convex root of the tongue, may be better cloſed or depreſſed. Hence it is neceſſary towards deglutition for the jaws to be cloſed, that by this means the biventer may have a firm ſupport; and, together with the muſcles already deſcribed, elevate the os hyoides. Thus the epiglottis, being inverted, ſhuts up and covers the paſſage very exactly, into the larynx, over which it is extended like a bridge for the aliment to paſs over into the fauces.

DCXIII. By the pharynx [153] we underſtand an ample ſhapeleſs cavity, extended from the occipital bone before the great opening of the ſkull downward, along the bodies of the cervical vertebræ, covered above by the middle cuneiform bone, the opening of the nares, and moveable velum of the palate, receiving the tongue and larynx before, and continued into the œſophagus below. Its ſides are formed by the lower jaw, the cheek, the velum of the palate, the pterygoid proceſs, the ſtiliform appendix, the tongue, os hyoides, and larger cartilages of the larynx. It forms one ſoft membranous bag, outwardly ſurrounded on all ſides by muſcular fibres. Internally it is lined with a membrane continuous to the cuticle, like which it is renewable, but more moiſt. Outwardly it is joined to the pharynx with a good deal of cellular ſubſtance, more eſpecially in its poſterior and lateral parts. By this ſtructure it becomes lax and dilatable, ſo as to receive all bodies that are preſſed by the tongue over the larynx.

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[153] It is moſt elegantly painted by Albinus, Courcelles, and Santorinus, on the back part; and by Camper internally.

DCXIV. It is dilated in its action (DCXII.) by the powers ſerving to its elevation; ſuch as the *ſtylopharyngeus*, ſometimes double, from the proceſs of its name; whence deſcending, it is inſerted into the membrane of the larynx, under the os hyoides, and into the cartilaginous edge of the deſcending thyreoideus; after which, it is broadly ſpread through the internal face of the pharynx, together with the following. The *thyreopalatinus*, being ſpread in the form of an arch round the moveable palate, is from thence extended downwards in two columns, on each ſide the pharynx, which form a conſiderable part of that bag, being alſo connected by broad fibres to the thyreoid cartilage. That the *ſalpingopharyngeus* is a true or diſtinct muſcle, I am ready to believe, rather from the obſervations of eminent anatomiſts, than any of my own. As to the *cephalopharyngeus*, I almoſt deſpair of finding any, unleſs you will reckon the ſtrong white plate of the cellular ſubſtance, which ſurrounds the upper part of the pharynx for a muſcle. This bag cloſely ſurrounds and follows the drink, on each ſide the epiglottis, above the larynx, that it may from thence fall into the œſophagus.

DCXV. That the aliments might not regurgitate into the noſtrils at the time when they are preſſed into the dilated pharynx (DCXIV.), a moveable velum or palate is interpoſed: namely, from the bony palate anteriorly, and laterally from the pterygoide wings, is continued a moveable velum, compounded of the membranes from the mouth and nares, betwixt which membranes are ſpread muſcles and glandules; being almoſt of a ſquare figure, and pendulous betwixt the cavity of the nares and fauces, in ſuch a manner, that they naturally leave the former open, and form a concave arch towards the mouth: and from the middle of this is extended a ſmall portion, pendulous, and of a conical ſhape, before the epiglottis, replete with many ſmall glands; which, from its appearance in a diſeaſed ſtate, is called *uvula*. The elevator of this velum, which is ſtrong, ariſes from the aſperities and plane face of the os petroſum, behind the ſpinal foramen; and from a cartilage of the tube deſcending inward, does, with its companion, form an arch, which is moveable with the palate itſelf, between the two plates of the thyreopalatinus muſcle, ſo as to be brought into a cloſe contact with the ſides of the nares and with the tubes, that none of the aliment may enter into either of them. But this elevator does not ſeem to have any conſiderable action in ſwallowing. At this time regurgitation into the noſtrils is prevented by a conſtriction of the muſcles of the pharynx, together with a depreſſure of the thyreopalatinus, which then manifeſtly draws the moveable velum downward and towards the tongue and pharynx. Add to theſe, the *circumflexus palati mollis*, which ariſes a little more forward from the ſame cuneiform bone, from the internal ſide of its wings, and from the inner wing, with the cartilaginous end of the tube, broad; and then, paſſing through a notch of the pterygoide hook, changes its direction, and aſcends with a radiated tendon through the upper membrane that covers the velum of the palate,

late, joins with its fellow, ſpreads over the other muſcles, and adheres to the edge of the palate bone. This is able both to open the tube, and to preſs down the moveable velum of the palate. Thus the pharynx being contracted like a ſphincter, drives down the food, without permitting any part to return back into the cavity of the nares. Hence, when the velum of the palate is vitiated, the aliments regurgitate into the noſtrils, and a deafneſs enſues.

DCXVI. During this endeavour to depreſs the food by the pharynx (DCXVII.), the velum, drawn back and expanded, is pulled down towards the tongue, by the action of the palatopharyngei, and by the circumflex muſcles of the ſoft palate. Theſe muſcles, together with the gloſſopalatinus, (which laſt is indeed weak, being received into the leſſer arch of the fauces, and here united with its companion into the arch by the velum of the palate, and from thence ſent to the tongue,) preſs the velum againſt the protuberant root of the tongue, and intercept any return to the mouth and noſtrils. After there is no further danger of any part falling into the windpipe, the epiglottis is raiſed up again, as well by its own elaſticity, as by the elevation of the tongue itſelf, by which it is drawn forward. Laſtly, the depreſſed uvula is raiſed by the azygos, which ariſes from the tendons of the circumflexi muſcles and levator of the ſoft palate.

DCXVII. A little after this follows an attempt to urge the food downward, which is exerted by the conſtrictor muſcles of the pharynx which draw the fore parts towards the back, and the muſcles which are partly tranſverſe and partly aſcend into the poſterior ſurface of the pharynx. Of theſe the principal is the pterygopharyngeus, ariſing from the whole hook and internal edge of the wing, and from the tendon of the circumflex muſcle; from whence forming an arch, it is extended upward and backward, and, largely ſurrounding the upper part of the pharynx, it joins into one with its companion, which has the ſame name. The mylopharyngeus,

geus, partly continuous with the fibres of the buccinator, in the middle betwixt its two adheſions to the bones, ariſes alſo in part from an origin of its own, above the laſt of the grinding teeth in the lower jaw. Theſe having a courſe almoſt tranſverſe, ſurrounding the pharynx, draw it back towards the fore part. Next to theſe follow the geniopharyngei, aſcending in two ſtrata of obſcure and confuſed fibres which originate from the tongue; next the chondropharyngei, of a triangular figure, ariſing from the oſſicula triticea; the ceratopharyngei, which aſcend radiated from half of the horn; the ſyndeſmopharyngei, ariſing from the horn of the thyreoide cartilage, and diſtinct from the former; to which add, the thyropharyngei of both kinds, increaſed by the fibres of the ſternothyroideus and cricothyroideus, with the cricopharyngei, the tranſverſe, the aſcending, and the deſcending. Theſe muſcles acting ſucceſſively from above downward, according to their ſituation, drive the aliment into the œſophagus. At the ſame time the depreſſing muſcles of the larynx, coracohyoideus, ſternohyoideus, and ſternothyreoideus, draw down the larynx forward, and leſſening the capacity of the pharynx urge the food downward. But in this action, as the aliment paſſes by the poſterior rima of the glottis, the arytænoidei contract the larynx perpendicularly.

DCXVIII. As various dry and rough bodies are frequently ſwallowed, it was neceſſary for the pharynx to be dilatable and not very ſenſible of pain; to which end the great quantity of mucus, which is collected in all parts of the fauces greatly conduces. Therefore, in general, betwixt the nervous and innermoſt coat of the pharynx, are placed a great number of ſimple mucous follicles or cells, of an oval figure, pouring out their mucus through ſhort mouths; of a ſoft, viſcid, and ſomewhat watery nature; but ropy, or drawing out into threads, not without oil, and abounding more with volatile ſalt and earth than the ſaliva itſelf. Theſe mucous receptacles are moſt plentiful in that part of the pharynx which is immediately extended under the occipital bone, where they are diſpoſed in a ſort of radiated right lines; and they are likewiſe numerous about the tonſil, toward its tube, where commonly the ſecond tonſil on each ſide lies adjacent to the large one, and in that portion of the pharynx which is called ſalpingopharyngeus. But there are likewiſe other flat and circular follicles, ſeated in great numbers about the back part of the tongue, as far as its foramen cæcum (CCCCXLVIII.) Other follicles and pores of the ſame kind are every where ſeated in the pulpy fleſh of the palate, where numerous ſmall glands diſcharge ſuch a viſcid mucus. Moreover, the whole ſurface of the moveable palate is of a glandular nature like that of the pharynx; only the follicles and glandular corpuſcles are here more numerous and thickly ſet together. Nor, laſtly, are lacunæ wanting, into each of which are joined many ſimple glandules.

DCXIX. Where the pharynx deſcends laterally from the little pterygoidal hook betwixt the two arches of the fauces, namely, between the gloſſopalatinus and pharingopalatinus, are ſeated the tonſils, of an oval figure, convex behind, and thick on the upper part, perforated inward with ten or more large ſinuſes, which open through the membranous covering of the velum extended over them, and by the preſſure of the adjacent muſcles diſcharge a great quantity of a moſt thick mucus from their ſinuſes. In like manner, the adjacent parts of the nares, and projecting ring of the tubes, and that ſide of the epiglottis which lies next to the larynx and the back of the arytænoide cartilages, are alſo repleniſhed with mucous organs. Laſtly, the œſophagus itſelf, on all ſides, abounds with ſimple follicles, from whence a mucus is poured out ſomewhat more fluid. But the larger glandulæ œſophagææ are of the conglobate kind, and conduce nothing to this mucus. The blood-veſſels of the tonſils are ſupplied from thoſe of the tongue, lips, and pharynx itſelf; as thoſe of the œſophagus are derived from the branches of the pharynx,

rynx, upper and lower thyreoidals, from the bronchials and aorta. The veins of the palate and tonſils being numerous, run together into a net-work, ending in the ſuperficial branch of the internal jugular.

DCXIX. The *œſophagus*, then, is a double tube, of which the innermoſt is ſeparated from the outer by a good deal of cellular ſubſtance, that may be inflated. The innermoſt tube of the œſophagus is nervous and ſtrong, being continued from the membranes of the mouth and nares, on its inner ſide plaited and porous, having an epidermis which is not villous, but pulpy, and exhaling a thin humour; it is diſtinguiſhed by a thin cellular ſubſtance, in which the ſmall veſſels are reticulated with minute glands interſperſed, which are continuous, and ſimilar to thoſe of the pharynx. The outer tube is muſcular, and in itſelf conſiderably ſtrong, compoſed of fibres internally continued from the lower and back part of the cricoide cartilage, which, by degrees, change from annular to fibres that are externally longitudinal, and ſerve to draw up and dilate the œſophagus againſt the food, that the mouthful may be received. But the other internal circular fibres, which are ſtronger than the former, ariſe in like manner from the top of the cricoide cartilage; and by their ſucceſſive contraction againſt the food, drive it down through the whole long tube of the œſophagus, which deſcends firſt in a direct courſe, a little to the left ſide of the windpipe; but having reached the cavity of the breaſt, it paſſes behind the heart, through the cellular interval that lies behind the bag of each pleura (LXXVII.); from whence, inclining by degrees a little to the right, it afterwards bends again forwards to its proper opening, by which its included food paſſes through the diaphragm (CCLXII.) in the interval of time that is betwixt exſpiration and inſpiration. Outwardly, the whole tube of the œſophagus is ſurrounded by the cellular ſubſtance, by which it is looſely tied to the neighbouring parts.

DCXX. The aliments are moved through the œſophagus

gus as through an inteſtine. The longitudinal fibres, aſcending to the cartilages of the larynx, dilate the gullet, oppoſite to the deſcending morſel. But when it is received, the longitudinal fibres equally dilate and elevate the gullet at that place which receives it. Then that part of the œſophagus where the morſel is ſeated, being irritated, contracts, and moves the food downwards. The muſcle is ſtrong, and very irritable.

DCXXI. This upper opening of the ſtomach is contracted or compreſſed in ſuch a manner, by the lower muſcle of the diaphragm, in every inſpiration, as to confine the food within the ſtomach, and direct it in every exſpiration, by preſſure, naturally towards the pylorus. By this means, the ſtomach is ſo cloſely ſhut, that in the moſt healthy man even wind or vapours are confined within the ſtomach; nor do they ever aſcend but by a morbid affection.

CHAP. XX.

Of the ACTION *of the* STOMACH *on the* FOOD.

DCXXII. BY the *ſtomach* we underſtand a membranous bag, deſtined for the reception of the food; placed within the cavity of the abdomen, behind the liver and left falſe ribs; in general of an oval figure or like a caſk; of a larger diameter tranſverſely, and this more ſo as the perſon is more adult; but in the fœtus it is altogether ſhort and round. But if we conſider more accurately every ſection of its figure, they will appear circular; although there be a blind or obtuſe concavity in its left extremity, from whence it grows wider towards the œſophagus, at whoſe inſertion its light or ſection is the largeſt of all; from thence it diminiſhes by degrees, till bending in a contrary direction to itſelf, it ends in the pylorus. Its bulk depends on the quantity of food, by which the cavity of the ſtomach is augmented; and, on the contrary, it is diminiſhed by famine. Its ſituation in general is tranſverſe; yet ſo that the œſophagus enters its poſterior ſide; and the pylorus goes out from it forward to the right ſide. The middle of the human body, or enſiform cartilage, thus covers or anſwers nearly to the centre of the ſtomach; but alſo to the right ſide, and laſtly to the pylorus; to the latter anſwers the umbilical fiſſure. Since its figure is round but incurvated, its lower convexity will form a larger pendulous arch when empty; but when full, it ſhows itſelf prominent before, and in contact with the peritonæum. On the other hand, the leſſer arch, intercepted betwixt the two orifices, will in this ſtate of the ſtomach lie perfectly backward towards the ſpine, ſo as to include the ſmall lobe of the liver. Thus the inſertion of the œſophagus into the full ſtomach will be in an obtuſe angle, in a manner parallel with the horizon; but in the empty ſtomach it will be almoſt perpendicular: and at the ſame time, the right extremity of the ſtomach forming the pylorus, which in an empty ſtate lies bent upward, will in the full ſtomach be bent more backward, ſo as to deſcend in perſons lying on their back. In a living man, that ſituation of the ſtomach which we have attributed to the full one is neareſt the truth.

DCXXIII. In the neighbourhood of the ſtomach lie the viſcera: and particularly to its large imperforated extremity is connected the ſpleen, by a conſiderable portion of the omentum; the leſſer arch or curvature of the ſtomach receiving the little lobe of Spigelius, as likewiſe the left lobe of the liver largely interpoſing betwixt the ſtomach and the diaphragm; which lobe compreſſes the forepart of the ſtomach; below the margin of which, a portion of the ſtomach lies immediately contiguous to the diaphragm itſelf; yet ſo as, by a moderate extenſion, to lie hid within the bounds of the falſe ribs. Under and behind the ſtomach, lies the pancreas, extended for a conſiderable length in an empty ſpace, upon the tranſverſe portion of the colon. Again, from the leſſer curvature ariſes the little omentum, to which is continued the ſtronger membrane that connects the œſophagus with the diaphragm: nor is the large omentum connected to the whole length of the ſtomach; but, leaving a deficiency to the right ſide near the pylorus, it is continued on beyond the left extremity, into a ligament which connects the ſtomach and ſpleen together. The ligaments, in theſe parts, are productions of the peritonæum; which, receding from the diaphragm, ſpreads itſelf over the ſtomach, ſo as to form its outermoſt coat. The pylorus lies between its mouths, on the forepart, more to the right ſide, and a little lower down.

DCXXIV. The fabric of the ſtomach anſwers in general to that of the œſophagus; of which, indeed, it is an expanſion; and, in ſome animals, has in all its parts the ſame appearance. The outermoſt coat is from the peritonæum, of conſiderable ſtrength, ſo as to limit the reſt, and afford a ſupport to the ſubjacent muſcular fibres: this is expanded into the little and great omentum, and in that place the ſtomach is without its outermoſt coat. Then follows the cellular coat more abundant in the origin of the little omentum, where it contains little conglobate lymphatic glandules, which alſo holds true of the cellular ſubſtance in the great omentum; but it is thinner and much leſs conſiderable betwixt the coats of the ſtomach iſelf, whence the outer and muſcular tunic cloſely cohere together: in this ſubſtance the larger branches of the veſſels are diſtributed.

DCXXV. Next in order appears the muſcular coat, neither eaſy to deſcribe or prepare. Here, indeed, we ſee the longitudinal fibres of the œſophagus, coming to the ſtomach, are detached one from another, along all the ſides of the ſtomach. Some of them, of more conſiderable ſtrength, run on to the pylorus, along the leſſer curvature; which, by degrees declining from their longitudinal courſe, following the length of the ſtomach, deſcend into a plain of each ſide, and are in part ſtretched out through the pylorus into the duodenum itſelf, where they gradually diſappear. Other fibres deſcend to the blind ſac of the ſtomach, ſeated on the left ſide.

And, finally, through every ſection of the ſtomach, from its blind or left extremity, to the pylorus, are ſpread concentric circular fibres, which, by degrees increaſing in their thickneſs or number, are continued on with the reſt of the circular fibres belonging to the ſtomach: this laſt makes the moſt conſiderable order of the muſcular fibres. Laſtly, the ſphincter of the cardia and œſophagus is compoſed internally of fibres, ariſing from the left ſide of the œſophagus, and running to the right, paſs on each ſide the gula, which they thus cloſely embrace, and then degenerate longitudinally till they are loſt under the circular or ſecond ſtratum near the pylorus. But the ligaments of the pylorus ſo called, are two conſtrictions, betwixt the two incurvations into which the pylorus is bent, formed by the foreſaid longitudinal fibres, which run along from the ſtomach to the pylorus, and are very cloſely joined to the internal coat in their way.

DCXXVI. Immediately under the muſcular fibres, follows another cellular ſtratum, larger than the outermoſt, ſofter, more eaſily inflatable, and conſiſting of larger cells or veſicles than what we uſually obſerve in the inteſtines. Within this cellular ſubſtance are ſpread the veſſels which, coming from the larger trunks, perforate the muſcular coat, and are divided into an angular network. Under this lies the nervous coat, which is thick, white, and firm, and properly makes up the true nature or ſubſtance of the ſtomach itſelf, after the manner of other nervous parts: and this is again lined internally with a third cellular ſtratum, evidently enough to be perceived, whoſe vaſcular net-work is much more minute than that of the former, from whence it is derived. Immediately within this lies the villous coat that lines the cavity of the ſtomach itſelf, continuous with the external cuticle, like which it is renewable; but of a ſoft mucous texture, and extended into a very ſhort pile, and folded into large plates, which form a ſtar under the œſophagus; but in the middle of the ſtomach, theſe folds are almoſt parallel with the ſtomach itſelf.

But, at the extremity of the pylorus, there is a more conſiderable fold, commonly called valvula pylori, which is formed by a production both of the tranſverſe muſcular fibres, and of the thicker nervous coat, extended together in the ſhape of an unequal looſe ring, produced towards the duodenum; this forms a ſlippery fleſhy protuberance, which ſurrounds the duodenum for a conſiderable length. The large wrinkles of the villous membrane are afterwards ſubdivided more minutely into others of a quadrangular or net-like figure; but very ſhallow and eaſily diſappearing, being much more obſcure than thoſe in the biliary ducts. Within this villous coat of the ſtomach throughout, but more eſpecially towards the pylorus, I have truly obſerved ſome pores, not always to be perceived, which terminate in ſimple follicles, ſeated in the next cellular ſtratum.

DCXXVII. The *veſſels* of the ſtomach are both numerous and derived from many trunks or various quarters, that the courſe of the blood through them might not be intercepted by any kind of preſſure, as might eaſily have been if the veſſels of the ſtomach had come from a ſingle trunk. The common mother of all theſe gaſtric arteries is the cœliac; from the threefold diviſion of which, or above the ſaid diviſion, ariſes the upper coronary, which is the firſt and largeſt artery that paſſes in a ſingle branch round the edge of the œſophagus into the ſtomach; to which, firſt, and afterwards to the diaphragm and to the liver, it ſends off ſome ramifications; and then running on the leſſer arch or curve of the ſtomach, it inoſculates by more than one branch with the leſſer coronary of the right ſide, ariſing from the right branch of the cœliac at the vena portarum, and is diſtributed along the leſſer curve of the ſtomach. But the ſame right branch of the cœliac, ariſing behind the duodenum, along which it deſcends, gives off a very conſiderable artery that runs contrary to the great arch or curve of the ſtomach, the *right gaſtro-epiploica*, which being ſuſpended in the omentum, it ſpreads itſelf both upon each ſide of the ſtomach, and upon the greater part of the omentum itſelf, being at laſt inſerted into the *left gaſtrico-epiploica*. Namely the left trunk of the cœliac, paſſing along in the direction of the pancreas and ſinuoſity of the ſpleen, there ſends off many branches to the ſtomach: of which the firſt are commonly nameleſs; and among the following, one branch, more conſiderable than the reſt, is called the *left gaſtro-epiploica*, which ſends off a conſiderable twig to the omentum, with ſome others that are ſmaller: from whence, deſcending round the ſtomach towards the right ſide, it inoſculates with the right artery, which is its companion. Other ſmaller ones, coming from thoſe of the ſpleen, are ſpread upon the greater curve of the ſtomach, even as far as the diaphragm, under the denomination of the *vaſa brevia*. Frequently, alſo, one or two arteries come from the ſplenic one, to the poſterior plate of the ſtomach under the œſophagus, in another line from the gaſtro-epiploics. The other ſmaller arteries are the upper ones of the pylorus from the hepatics, and the lower ones from the gaſtro-epiploics: but thoſe of the lower part of the œſophagus are from the phrenic arteries.

DCXXVIII. Thoſe arteries ar diſtributed in ſuch a manner, that firſt they ſend off ſhort twigs to the external and to the muſcular membranes of the ſtomach; their trunks are ſet in order in the firſt cellular ſtratum; from whence, diminiſhing a little in ſize, they penetrate through the muſcular coat; and between that and the nervous membrane, they compoſe a larger and true net-work; in which all the ſmall arteries, coming from a great variety of trunks, join one with another, by an infinity of inoſculations. From this plexus, again, other ſhort, but numerous and very ſmall ramifications, paſs through the nervous coat to the third or inner cellular ſtratum, and are loſt in the villous lining of the ſtomach.

DCXXIX. The *veins* have their branches diſtributed in company with the correſponding arteries. The greater coronary from the left ſide of the ſtomach, generally goes to the trunk of the porta, together with the brevia and left gaſtro-epiploic; while the right vein of the laſt denomination joins with the middle vena colica, and, together with a branch from the meſentery, pours its contents into the vena portarum. Finally, the right coronary vein belongs to the trunk of the vena portarum itſelf. All theſe veins are without valves; and, like the arteries, there are upper coronary veins, with others of the œſophagus from the thorax, all communicating together by inoſculations, in ſuch a manner, that there is a free paſſage for the blood thence into the vena azygos, with which they inoſculate.

DCXXX. The *nerves* of the ſtomach are both large and numerous, produced from the eighth pair, forming two complications about the œſophagus, of which the anterior and leſs plexus deſcends through the upper or outer ſide of the ſtomach to its greater curve; and the poſterior plexus, which is larger, is diſtributed through the leſſer arch of the ſtomach; from whence it paſſes, together with the arteries, to the liver, pancreas, and diaphragm itſelf. Theſe nerves may be every where traced into the ſecond cellular ſtratum. The remainder, but eſpecially the papillæ, are more obſcure. From their number, the ſtomach is extremely ſenſible, inſomuch, that things which make no impreſſion upon the tongue, will nauſeate and pervert this organ, which is capable of much ſeverer pain than the inteſtines; as we know from infallible experience in diſeaſes: even the ſkin itſelf, when naked by a bliſter, is leſs ſenſible than the ſtomach. By making a ligature upon the nerves of the eighth pair, both the action of the ſtomach and the digeſtion of the food ceaſe.

DCXXXI. *Lymphatic veſſels* I have obſerved, ſometimes very conſiderable, about the leſſer curve of the ſtomach, ariſing from the glandules of that part, and inſerted by a very large trunk into the thoracic duct. Others, no doubt, ariſe from ſmall glandules of the ſame kind in the greater curve; and ſome famous anatomiſts have obſerved lymphatic glands over the whole ſtomach.

Other lacteal veſſels, I have neither ſeen, nor am ready to admit; ſuch as thoſe lately deſcribed, which are ſaid to paſs from the ſtomach through the omentum to the liver, filled with a true chyle.

DCXXXII. All parts of the human ſtomach are perforated by inorganic pores, through which water injected both exhales through the ſtomach when ſhut, and, on the contrary, penetrates the cavity of the ſtomach when put under water. But we cannot for this reaſon conclude, that in a living perſon this paſſage lies open for moiſture.

DCXXXIII. Within the human ſtomach, we firſt meet with a great quantity of *mucus*, ſpread upon its villous lining, from the pores before deſcribed (DCXXVI.); which mucus is not unfrequently tinged, by ſome of the bile returning into the ſtomach. Beſides this, in an empty ſtomach after faſting, upon bending the body, a great quantity of a *limpid humour* will ariſe into the mouth, altogether of the ſame nature with the ſaliva, but more mucous; which liquor is very rarely to be found pure or unmixed in the ſtomach. It is very far from poſſeſſing any acid acrimony, when it can be had pure from the food. Left to itſelf, it changes, both in man and brutes, rather to a lixivial or alkaline nature, when it is ſeparated from the acid illuvies of the aliments, more eſpecially in an hungry animal. This liquor diſtils from the arteries of the ſtomach, through its villous coat, after the manner we ſee by anatomical injections: by which, water, fiſh-glue, and oil, may be eaſily urged into the veſſels of the ſtomach, ſo as to ſweat through its numberleſs pores.

DCXXXIV. The ſtomach then, contained within the abdomen, which is perfectly full, will from thence, as in a preſs, receive a force or compreſſure upon its ſides, which lie betwixt the diaphragm; the concavity of whoſe right wing is filled by the liver, under which, and within the left wing, lies the ſtomach, extended almoſt tranſverſely behind the reſiſting muſcles of the abdomen, viz. the recti and obliqui, but chiefly the tranſverſe. The more the ſtomach is filled, the more it is urged by this preſſure of the abdominal muſcles; becauſe, at the ſame time, it riſes upward in a right angle to the contact of the peritonæum.

DCXXXV. Now we muſt ſpeak of what is received into the ſtomach, and why it is received. The Creator has given to man the two faithful guards of pleaſure and pain (DLXIV.) for his preſervation; the one to avert evil, the other to invite him to uſeful actions. But the taking of aliment is an action very neceſſary and uſeful to our ſupport. For ſince every day there is a great quantity waſted from the body, by a diſſolution of its true ſubſtance thrown off by perſpiration, a repairing of this loſs is every way neceſſary, as the body is manifeſtly waſted by faſting. But this neceſſity of taking food recurs the more quickly from the nature of the blood itſelf, which is ſtrongly inclined to a ſharp, ſaline, lixivial quality, and to a putrid acrimonious ſtate; to which laſt it is continually ſolicited, and approaches, from the putreſcent diſpoſition of all the more ſtagnant humours of the animal, promoted by the inceſſant and natural motion of the heart and arteries, and by the heat which very much promotes the putrefaction of all the animal humours. Moreover, the coagulable diſpoſition of the blood, continually loſing a great part of its diluting water by inſenſible perſpiration, calls ſtrenuouſly for a recruit of the watery element, in the way of drink, by which its coheſive globules are ſeparated from each other, and hindered from running together into a conſiſtent maſs.

DCXXXVI. Theſe truths are proved not only from their cauſes, but likewiſe by the appearances which they exhibit in men and other animals killed by hunger. For, in ſuch, we commonly obſerve a ſharp ſtinking breath, a looſeneſs of the teeth from the diſſolving acrimony of the juices, violent pains in the ſtomach, ſharp fevers, and even a true madneſs. All theſe diſorders ariſe ſooner and ſtronger, as the perſon is more robuſt and more violently exerciſed with motion of body; but they enſue very ſlowly in phlegmatic people, who are unactive, perſpire little, and put the blood into no great motion. Laſtly, thoſe who have been without food, have alſo lived without bodily exerciſe, and for the moſt part laboured under a diſeaſe of the nerves.

DCXXXVII. The freſh chyle, compoſed, for the moſt part, out of the aceſcent claſs of vegetables, and of a conſiſtence always thinner than that of the blood itſelf, being received into its torrent of circulation, temperates the putreſcent acrimony, dilutes the coagulation threatened, and reduces the whole maſs to that moderate degree of ſaline narure which is natural to man: and finally, the chyle, but more eſpecially that derived from the fleſh of animals, and likewiſe what is formed of farinaceous vegetables, being repleniſhed with gelatinous lymph, ſerves to repair the conſumption or waſte which is made from the body itſelf, to the vacuities of whoſe broken ſolids it is applied by the cauſes mentioned (DCCCCLIX.) The drink dilutes the coheſive or grumous inclination of the blood, hinders its putrefaction, and carries off by the emunctories ſuch particles as are already putrid: and hence it is, that a perſon may live for a long time without ſolid food, if he is ſupplied with drink; but without drink, life ſubſiſts but a few days.

DCXXXVIII. We are ſolicited to take food, as well from the ſenſe of pain we call hunger, as from that of pleaſure, which is received by the taſte (CCCCLV.) The firſt of theſe proceeds doubtleſs from the ſenſible folds or wrinkles of the ſtomach rubbing againſt each other by the periſtaltic motion, of which there is an acute ſenſation, joined with a preſſure from the diaphragm and abdominal muſcles, by which the naked villi of the nerves on one ſide grate againſt thoſe of the other, after a manner intolerable. Thus we are effectually admoniſhed of the dangers enſuing from too long abſtinence or faſting, and excited to procure food or nouriſhment by labour and induſtry. To this ſenſe perhaps the gaſtric liquor or juice of the ſtomach, collected and ſharpened after feeding, does in ſome meaſure conduce, unleſs it becomes putreſcent,

DCXXXIX. *Thirſt* is ſeated in the tongue, fauces, œſophagus, and ſtomach. For whenever theſe very ſenſible parts, which are conſtantly and naturally moiſtened by mucous and ſalival juices, grow dry from a deficiency of thoſe or the like humours, or are irritated by a redundancy of muriatic or alkaleſcent ſalts here lodged, there ariſes a ſenſe much more intolerable than the former, as thirſt is more dangerous; whoſe uneaſy ſenſe continues until the proportion of diluting water in the blood, being recruited, reſtores the neceſſary moiſture and free ſecretion required in the parts before mentioned. From hence we learn, why thirſt attends labour, which exhales a greater proportion of the watery perſpiration; and why it is a ſymptom of fevers, where there is an obſtruction of the exhaling veſſels belonging to the tongue and fauces; why ſimple water is leſs efficacious in abating thirſt, which yields nevertheleſs eaſily to ſome acid liquors, that not only moiſten and render fluid, but alſo, by their mild irritation of the tongue and mouth, provoke forward the humours, and at the ſame time correct their putrid tendency.

DCXL. From theſe cauſes, mortals, being under a neceſſity of ſeeking food for the ſupport of life, have in all ages determined their choice to the ſucculent parts of vegetables, and animals, in ſuch a manner, that water and ſalt ſeem to be added only as third aſſiſtants. And firſt, it is probable, that the primitive choice of our foods was made by experiments, according as the variety of ſmells and flavours in vegetables and their ſeveral parts invited, and as the ſtrength or recruit of our faculties thence following confirmed their utility. But by degrees, animals increaſing ſo much as to be incommodious to the huſbandman, and vegetables alone not being ſufficient for ſupporting them under their labours, the fleſh of animals was afterwards added. At preſent, both the number and variety of ſubſtances are almoſt infinite, which we take either as food or ſeaſoning for our nouriſhment.

DCXLI. Although there are many inſtances of particular perſons, and even of whole nations, who have ſupported life only with one kind of food, either vegetable or animal, or even from a ſmall claſs of either of them; and laſtly, though ſome have lived altogether upon milk or its whey; yet it ſeems to be neceſſary, both from the nature and fabric of the human body itſelf, as well as from certain experiments, that we ought to ſupport life by the two kinds of food, ſo intermixed, that neither of them may exceed their reaſonable bounds; and this mediocrity we are taught from the loathing itſelf, which follows to any one kind of food that has been continued for too long a time together.

DCXLII. The fleſh of animals appears a neceſſary part of our nouriſhment, even from the fabric of the human ſtomach itſelf, reſembling that of carnivorous animals; and from the two rows of teeth, with the canine teeth in each jaw; alſo from the ſmallneſs and ſhortneſs of the inteſtinum cæcum, and from the neceſſary vigour which we require. For the fleſh of animals alone contain the gelatinous lymph ready prepared for the recruit both of our fluids and ſolids, which, being extracted from the broken veſſels and fibres, eaſily paſſes in great abundance into the blood. An abſtinence from animal food generally cauſes great weakneſs both to the body and ſtomach, being perpetually attended with a troubleſome diarrhœa But in the amplitude and length of the inteſtina craſſa, man agrees with herbivorous animals.

DCXLIII. Eſculent vegetables are generally of the aceſcent kind; only ſome few of them are either alkaleſcent, or elſe repleniſhed with a ſpicyneſs. But few of them have that animal glue which is ſpontaneouſly changeable into blood; for it is only the ſmall portion of jelly which is drawn from their farinaceous parts, that, after many repeated circulations, is converted into the nature of our indigenous juices. Yet theſe are neceſſary to avoid over repletion with blood, and of too putreſcent a kind from the uſe of animal food alone, which, from the moſt creditable accounts of the anthropophagi, prevails to ſo great a degree as to breed the hot alkaleſcent ſcurvy, a fierce or ſavage temper, a ſtinking and leproſy of the body, with a lixivial corruption of all the juices; which are only to be cured by change of diet, in which a vegetable acidity abounds. Hence it is, that we are furniſhed but with few canine teeth; and that our appetite in health, but more eſpecially in diſeaſe, is ſtronger for acidulous vegetables, in proportion to our warmer temperature of body, and greater heat of the country or the ſeaſon of the year. Hence we ſee, that in the hotteſt climates, people live either altogether upon vegetables, or uſe fleſh meats but very rarely, and not without danger of acute diſeaſes; while, in the colder countries, fleſh is eaten freely with leſs danger: and hence bread, or a farinaceous aliment ſimilar to it, is made a ſtanding part of our food throughout the world.

DCXLIV. The beſt *drink* is afforded by pure water, not incorporated with ſalts, nor with air, which may excite fermentations. Of this kind we juſtly prefer that from a mountainous ſpring, which runs through a ſandy bed, being very cold, clear, light, and inſipid. Whenever we are unprovided with ſuch pure water, as is frequently the caſe in the lower flat countries, or when any increaſe of the ſtrength and muſcular conſtriction of the ſtomach is required from a ſpicy ſtimulus, its place may be very well ſupplied by wine, prepared chiefly from grapes; but, in defect of thoſe, from apples and pears; which, after a due fermentation, becomes clear, and is repleniſhed with an acid ſalt, and oily or inflammable ſpirit, well diluted in water. Liquors of the ſame kind, repleniſhed with a vinous or inflammable ſpirit, but more flatulent, heavy, and leſs palatable, are prepared from corns roaſted, afterwards extracted with boiling water, and prepared by fermentation,

tion, as a ſubſtitute for wine in thoſe countries where the grape does not ripen.

DCXLV. But mankind have invented various pickles and ſauces, ſuch as ſalt, vinegar, and acids of various kinds, to correct the putreſcent diſpoſition of fleſh-meats; with pepper, muſtard, and other hot ſpices, to ſtrengthen the action of the ſtomach, which is perpetually weakened by the uſe of vegetables: and to theſe add, ſugar, ſalt, and the eaſtern ſpices, which are generally added either for the ſake of flavouring or preſerving our food. But all theſe yield no nouriſhment, being deſtitute of all gelatinous lymph, or any farinaceous quality. The ſpirits of wine and corn may be of ſome uſe as medicines, but are unfit for drinking.

DCLXVI. The aliments are variouſly prepared, according to the difference of country, climate, or ſeaſon; and thus their crudity is removed, their ſolid fibres ſoftened, their ſuperfluous air expelled, and their diſagreeable acrimony changed and rendered agreeable. But, even after this, many vegetable foods, and more eſpecially fleſh-meats, require to be divided, in ſome degree, by a previous triture in the mouth, which is particularly neceſſary in man, whoſe ſtomach is but little fleſhy, and likewiſe that the food may not ſtay ſo long upon the ſtomach as to become putrid.

DCXLVII. The meaſure of our food is determined by hunger, which is different according to the difference of bodies. Animal and farinaceous food nouriſhes moſt: other aliments ought to ſupply by their quantity, what they want in their powers of nouriſhment. In general, we are nouriſhed beſt by a ſomewhat ſpare diet, unleſs ſubjected to much labour.

DCXLVIII. Into this ſtomach, therefore, the aliments are let down, often almoſt crude, and but little chewed, of various kinds; ſome of them being alkaleſcent, as fleſh-meats; ranceſcent, as oily or fat ſubſtances; or aceſcent, as bread, milk, and moſt of the vegetable kind. Theſe, we obſerve, are digeſted in a heat equal to that of an hatching egg, adminiſtered to the ſtomach by the contiguous ſpleen, liver, and heart; and this in a cavity altogether cloſe or confined, above (DCXXI), as it alſo is below, by the aſcent of the incurvated pylorus, and in a great meaſure by a ſhutting valve, and likewiſe conſtringed by a muſcular force of the fibres; from whence we obſerve, that even milk itſelf is often retained in the ſtomach of ſtrong animals ſeveral hours after a meal, without paſſing into the inteſtines. Obſerve, again, that theſe aliments are continually cohobated or moiſtened with watery juices and at the ſame time are repleniſhed with a good deal of air incorporated with them, either naturally or in the maſtication. This air, therefore, expanding by the force of heat, putrefaction, or fermentation, breaks open the cells by which it was included, divides the viſcid liquors, and ſoftens or opens the ſolid fibres, ſo as to make a way for diſcharging their juices. But the ſame ſubſtance of the air, turning to a ſolid, makes the principal glue or cement by which the animal ſolids and other bodies receive their firmneſs; and this, being extricated by heat, leaves the other elementary parts friable, or without a vinculum, as we ſee from the change which happens in Papin's digeſter, in the ſtomachs of many animals, and even in that of ourſelves. This air, ſet at liberty by the digeſtion, often diſtends the ſtomach more than the food itſelf, under the denomination of flatus. While this air is extricated, the aliments by long ſtay begin to corrupt or change into a nauſeous liquid, often aceſcent; or otherwiſe putreſcent, which however happens leſs in mankind from our uſe of bread and ſalt; or ranceſcent, as appears from the flatus and matters eructated, often of a moſt fetid, cauſtic, and inflammable nature, from ſubſtances of the like diſpoſition. This putreſcency, or imperfect putrefaction, is almoſt the only cauſe of digeſtion in fiſh, ſerpents, and carnivorous birds. Hence, in mankind, metals themſelves, by long ſtay in the ſtomach, grow ſoft, and are eroded. At this time hunger is abſent, the nervous plates of the ſtomach being removed and defended from their contacts with each other by the interpoſed aliment, at the ſame time that the juice of the ſtomach itſelf is leſs ſharp and freer from a mixture with the old remains of the laſt food, which often excite a nauſeating uneaſineſs in the nerves of the ſtomach.

DCXLIX. But that the aliment might not degenerate into a complete acidity, there is a check from the putreſcent degree of the heat, the power of the juices diſtilling from the ſtomach, and that of the ſaliva itſelf, ſwallowed to the amount of half an ounce in an hour, and rather inclined to an alkaleſcency: alſo theſe juices being ground together with the aliment, macerate, ſoften, and diſſolve the fibres themſelves and their cellular bands, leaving them a ſoft pulp like what we ſee by letting them ſtand for a long time in warm water, extract their juice, and mingle it with themſelves. There is therefore no particular kind of ferment in the ſtomach[151]; from which the deſign of nature, the diſpoſition of the ſtomach, and its uſe, are all very remote. And yet the juice of the ſtomach alone, by its longer ſtay in fiſhes, diſſolves the bones which they had devoured.

DCL. For the fleſhy fibres in the ſtomach being now irritated by the flatus, weight, and acrimony of the food, begin to contract themſelves more powerfully than when the ſtomach is empty, and with a greater force in proportion as it is more full, the round ſwelling of which ſtretches theſe fibres. And, firſt, the muſcular ſtratum, which paſſes along the leſſer curvature, connects the pylorus with the œſophagus; and, being inſerted only into the left face of the former, draws it to the right. The principal ſtratum of the circular fibres contracts the capacity of the ſtomach, acccording to its length; grinds or intermixes its contents

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[154] The ſtomach's action upon the food, which is performed in ſome by fermentation alone; in others by putrefaction; in many by trituration; in ſome, in ſhort, by maceration alone; is carried on in none by real alkaleſcence. In man, who is furniſhed with a weak ſtomach, digeſtion goes on by means of ſeveral cauſes co-operating, which are fully deſcribed by M'Bride.

tents together with the liquors (DCXXXIII.); and determines them both, like the preſſure of two hands placed oppoſite, to flow towards the pylorus: but this flux through the pylorus is not made continually, for reaſons before aſſigned (DCXXVI.), as well as becauſe this motion begins from ſome part that is more irritated; and from thence the aliment is driven here upward, as in other parts downward. Theſe alternate contractions at laſt terminate in a full evacuation. In this action of the ſtomach, there is nothing which reſembles the triture made by the ſtrong gizzards of granivorous fowls, which ſome anatomiſts have aſcribed to the human ſtomach; which yet has a conſiderable degree of ſtrength, ſince the contraction of its fibres is often more than a third part of their length; for we frequently ſee the ſtomach reduced to leſs than a third of its diameter: frequently alſo the ſtomach is obſerved to be diminiſhed to much leſs than a third part, even to the breadth of an inch; which, laſtly, makes it fit for moving forward ſharp-pointed ſubſtances. Yet it neither bruiſes berries nor the ſofteſt worms.

DCLI. But that motion which it receives from the diaphragm and muſcles of the abdomen, is ſtronger than the periſtaltic force of the ſtomach; for, by this, the ſtomach is more perfectly emptied by a cloſe approximation of its anterior and poſterior ſides. For it is principally by this force that the drinks are urged on continually, but the foods only when they are diſſolved, leſt thoſe parts which are too groſs ſhould be expelled through the pylorus into the duodenum, when the ſtomach is more that way inclined by repletion; for the ſolid aliments do not ſeem to leave the ſtomach, before they have changed their fibrous or other texture for that of a mucous, as it were cineritious, yellowiſh, ſomewhat fetid, mucilaginous, and liquid pulp. That which is firſt prepared and turned fluid, goes before the reſt out of the ſtomach; firſt water; then milk, pot-herbs, bread; and laſt of all, fleſh-meats, the harder, tougher, and longer ſkins or fibres of which paſs unchanged: but ſuch things as are hard, or too large to paſs the pylorus, are retained in the ſtomach for a long time.

DCLII. But a conſiderable portion of the drink is abſorbed by the pendulous inhaling veins of the ſtomach itſelf, gaping like the exhaling arteries of the ſame part (DCXXXIII.); ſo their contents take a ſhorter way into the blood, as plainly appears from repeated experiments of injecting the veins. Does any thing paſs into the lymphatic veſſels (DCXXXI.)?

DCLIII. The ſtomach, being irritated by too great a quantity or acrimony of the food, or elſe by ſickneſs, a repulſion of the bile, or other cauſe, does, by an antiperiſtaltic or reverted motion of its fibres, drive its contents upward, through the open and relaxed œſophagus, in the act of vomiting[155]. But then this effect is partly from the preſſure of the abdominal muſcles, depreſſing the falſe ribs, and urging the contents of the abdomen againſt the diaphragm; which at the ſame time contracting itſelf to a plain downwards, forces the ſtomach, as betwixt the ſides of a preſs, to throw up its contents.

DCLIV. But the aliments, driven in their natural courſe to the duodenum, meet there with the influent bile and pancreatic juice, which often flow back into the ſtomach. But the former of theſe being the principal baſis of chylification, will require from us a previous hiſtory of the viſcera, which convey their blood through the vena porta.

CHAP. XXI.

Of the OMENTUM.

DCLV. BY the *peritonæum*, we underſtand a ſtrong ſimple membrane, by which all the viſcera of the abdomen are ſurrounded, and in a meaſure ſuſtained.

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[155] Any part of the whole inteſtinal canal, from the pharynx to the rectum, may be conſtricted, as well ſlowly as ſuddenly, by an antiperiſtaltic motion. If it happens ſuddenly to the upper parts at

tained. Internally this membrane is exceedingly ſmooth, and moiſtened with exhaling vapours: but outwardly it adheres to all the parts by the looſe cellular ſubſtance; which, towards the kidneys, contains a good deal of fat; but is extremely thin and ſhort before, betwixt the peritonæum and tendons of the tranſverſe muſcles of the abdomen. It begins from the lower ſide of the diaphragm, which it lines; and in certain intervals, joining with the correſponding pleura above, it completes what would be otherwiſe deficiencies in the diaphragm, as betwixt the ultimate fleſhy fibres next the ribs and at the loins; to which add, its continuations upward, through the foramina of the diaphragm. From thence this membrane deſcends, in its fore-part, behind the abdominal muſcles; in its back part, before the kidneys; and, going into the pelvis, from the bones of the pubes, it paſſes over the bladder obliquely backward; and then reaſcends back over the ureters by two lunar folds or plates, rejoining upon the inteſtinum rectum with that part of itſelf which inveſted the loins, and in the ſame place goes before the rectum.

DCLVI. The cellular texture which covers the peritonæum on the outſide, is continued into ſheaths in very many places; of which one receives the teſticle on each ſide; another the iliac veſſels; others the inteſtinum rectum, the larger veſſels of the pelvis, the obturatoria, penis, bladder, and aorta, and accompany the gullet, aſcending into the breaſt, and along the vertebræ; by means of which, there is a communication between the whole body and the peritonæum, very remarkable in dropſical people.

DCLVII. But through this general extent, it ſends out various productions for covering the viſcera. The ſhorter productions of this membrane are called *ligaments*;

at the ſtomach, the ſeptum tranſverſum being at the ſame time convulſed, and likewiſe the abdominal muſcles, it is called *vomiting*. If it is ſlowly performed, it may be called *ruminatio*. If the ſmall, and particularly the great inteſtines, return their contents upwards, the diſeaſe is called *ileus*.

ments; and are all of them formed by a continuous reduplication of the peritonæum, coming from its inner ſurface, together with a cellular ſubſtance, interpoſed and extending to ſome one or other of its viſcera, where its plates ſeparate again from each other to embrace the organ, which they are to ſurround and furniſh with a coat; but the cellular ſubſtance always intervenes betwixt this membranous coat of the peritonæum, and joins with it the true fleſhy ſubſtance of the viſcus. Of productions of this kind, there are three ſhort ones belonging to the liver, one or two to the ſpleen, and others to the kidneys and lateral parts of the uterus and vagina. By this means the tender ſubſtance of the viſcera is defended from injury by any motion or concuſſion; and their whole maſs is prevented from being miſplaced by their own weight, by their firm connection with the peritonæum.

DCLVIII. But the moſt noted of all theſe productions from the peritonæum, are thoſe called the *meſentery* and *meſocolon;* the deſcription of both which, although difficult, ought not to be ſeparated from that of the peritonæum itſelf. We ſhall, therefore, begin firſt with a deſcription of the *meſocolon*, as being the more ſimple. In the pelvis, the peritonæum ſpreads itſelf within a ſhort compaſs before the rectum; but where that inteſtine bends into a ſemilunar curve, the peritonæum there departs out far from the iliac veſſels and ſeat of the pſoas muſcle which lie upon the muſcles of the loins, and ariſes as if duplicated (DCLVII.), ſpreading itſelf in ſuch a form as is fitteſt to receive the colon into its capacity. But above, on the left ſide, that the colon might be at liberty, it is conjoined to the peritonæum, with little or none of this middle production; ſpreading itſelf upon the body of the pſoas muſcle, as high as the ſpleen, where this part of the peritonæum, that gave a coat to the colon ſpread under the ſpleen, receives and ſuſtains that viſcus, by taking it into its capacity or folds.

DCLIX. Then the peritonæum aſcends forwards from both kidneys, the interjacent ſpaces between them, and from the large blood veſſels, under the pancreas; to which being continuous, it forms a long production, called the *tranſverſe meſocolon*, which, like a partition, divides the upper part of the abdomen, containing the ſtomach, liver, ſpleen, and pancreas, from its lower cavity. The lower plate of this tranſverſe production is ſingle, continued from the right to the left meſocolon, and ſerves as an external coat to a large portion of the lower and deſcending part of the duodenum. But the upper plate, taking a more obſtructed courſe, departs from the lumbar peritonæum at the kidney and ſeat of the vena cava, farther to the right than the duodenum, to which it gives an external membrane, not quite to the valve of the pylorus; and, beyond this inteſtine and the colon, is joined with the lower plate in ſuch a manner, that a large part of the duodenum lies within the capacity of the meſocolon. Afterwards, near the liver, the meſocolon bends itſelf inward, and deſcends laterally over the kidney of the ſame ſide ſo as to include the right colon, which is much ſhorter than the left, even as far as the inteſtinum cæcum, reſting upon the iliac muſcle; to the appendicle of which, a peculiar long detachment adheres, as a beginning to the meſentery. There the meſocolon terminates almoſt at the bifurcation of the aorta.

DCLX. The whole meſocolon, and the whole meſentery, is hollow; ſo that air may be forced in between its two ſimilar plates in ſuch a manner as to expand it into a bag. At the place where the colon ſuſtains it, and alſo from part of the inteſtinum rectum, the meſocolon, which is continuous with the outer membrane of the inteſtine, forms itſelf into ſmall ſlender bags, for the moſt part double, thick, and bifid, free at their extremities, and capable of admitting air driven in between the plates of the meſocolon.

DCLXI. From thence forward the *meſentery* follows, as a broad plaited production of the peritonæum, continuous with the tranſverſe meſocolon, and extended on the right ſide forward, and downward from the emerging duodenum; and then from the left or long meſocolon, even as low as the pelvis. Thus the meſentery is formed by the plates of the peritonæum, which lie upon the aorta, extended forward and together, under the right portion of the tranſverſe meſocolon; and, deſcending obliquely under the pancreas, it contains the long ſeries of the ſmall inteſtines, within its capacity, diſpoſed in numberleſs folds.

DCLXII. The whole ſeat and extent of the meſentery and meſocolon contains a portion of fat, collected in greater quantity as they go farther within the capacity that is neceſſarily formed by the reduplication of their membranes, and veſſels are interſperſed ſurrounding the fat, which the arteries ſeparate, and the veins, as will be mentioned, reabſorb; there are alſo very numerous glands, which are moſt conſpicuous in a young perſon.

DCLXIII. The ſtructure of the *omentum* anſwers very nearly to that of the meſentery. But there are many membranes that come under this general denomination, of the ſame ſtructure and utility, all compoſed of very tender and fine membranes, eaſily lacerated, betwixt which the blood-veſſels are diſpoſed reticularly, with fat depoſited in ſtreaks near the ſides, and in the ſame directions with the reticulated veſſels themſelves. This membrane is always double; the two plates of which are joined together cloſely by a very tender cellular ſubſtance, within which the veſſels are diſtributed, and the fat collected. And, firſt, where the top of the right kidney and the inſulcated lobe of the liver, together with the ſubjacent blood-veſſels, meet with the duodenum into an angle, there the external membrane of the colon, which comes from the peritonæum, joining with the other membrane of the duodenum, which is alſo from the adjacent peritonæum, they go together over the left kidney backward, and enter into the tranſverſe fiſſure of the liver, for a conſiderable length; from which the external membrane is continued over the gall-bladder which it contains, confining the vaſcular fabric of the liver, very ſlippery, and tinged of a yellow colour. Behind this membranous production, betwixt the adjacent duodenum, right lobe of the liver, hepatic veſſels, vena portarum, and biliary ducts and artery, lies a ſmall natural opening, by which inflated air is largely received into all that cavity of the omentum which we ſhall preſently deſcribe as a bag; and, laſtly, into the bags of the reſt of the omentum.

DCLXIV. From thence in a courſe continuous with this membrane (DCLXIII.) from the pylorus and the leſs curve of the ſtomach, the outer membrane of the liver joins in ſuch a manner with that of the ſtomach, that the thin membrane of the liver is continued out of the foſſa of the venal duct, before the little lobule, into the ſtomach itſelf, ſtretched both before the lobule and before the pancreas. This is called the *little omentum hepatico-gaſtricum;* which, inflated, reſembles a cone; and, hardening by degrees when it is without fat, changes into a true ligament, by which the œſophagus and liver are conjoined together (DCXXIII.)

DCLXV. But the great *gaſtrocolic-omentum* is of a much larger extent. It begins at the firſt joining of the right gaſtro epiploic artery to the ſtomach, where it is continued from the upper plate of the tranſverſe meſocolon (DCLIX.); and from thence it proceeds forward along the great arch or curve of the ſtomach to the ſpleen, and in part is continued alſo from the right convex end of the ſtomach towards the ſpleen, even till it degenerates into a ligament that ties the upper and back part of the ſpleen to the ſtomach. This is the *anterior leaf* of the omentum.

DCLXVI. This anterior leaf or lamina of the omentum floats looſely downward before the inteſtines, ſometimes to the navel, ſometimes to the pelvis, behind the muſcles of the abdomen; and, making a thin edge, is folded back again in a direction contrary to itſelf, and aſcends ſo as to leave an intermediate vacuity, by which the fore leaf is removed from the poſterior; and being at length continued for a conſiderable extent into the outer membrane of the tranſverſe colon, and laſtly continued in the ſinus of the ſpleen by which the larger blood-veſſels are received, it ends in the œſophagus, under the diaphragm. Behind the ſtomach, and before the pancreas, the cavity of this is continued into that of the leſſer omentum.

DCLXVII. To this is continued the omentum colicum, which ariſes on the right ſide only from the colon and its external membrane, immediately after the origin of the omentum gaſtrocolicum from the meſocolon, with whoſe cavity it is continuous, but produced by the colon and its membrane, which departs doubled from the inteſtine, forms a production ending conically, and is terminated by a longer or ſhorter extent above the inteſtinum cæcum.

DCLXVIII. The uſes of the omentum are many. Its common uſe is, together with that of the meſentery, to form an ample ſpace, of a looſe texture, into which the fat may be poured from the arteries, at the time of ſleep and inactivity of body, to be afterwards diſſolved by motion, and returned again into the blood by the inſorbent veins, ſo as to make a conſtituent principle of the bile. Accordingly, you will feel the fat of the omentum to be very tenacious or viſcid betwixt the fingers, although of a thin conſiſtence, and in its whole body more pellucid than paper. For that the fat of this part returns again into the veins, appears from the different bulk and weight of fat obſervable in the various omenta of different perſons, according as they lead either an idle, laborious, or morbid courſe of life; to which add, its appearances in various brute animals, with the relation it bears to all the reſt of the fat of the body (XX.): from experiments in frogs, where this re-abſorption of the fat may be made evident to the eye: and, laſtly, from the apparently inflammable nature of the bile itſelf. To this we muſt alſo refer the diſorders and crudities of digeſtion, together with the coldneſs of the ſtomach, obſerved to follow after cutting out the omentum.

DCLXIX. For all the blood which returns from the omentum and meſocolon, goes into the trunk of the vena portarum, and by that into the liver itſelf. The omentum is furniſhed with blood by the gaſtrocolic and by each of the gaſtro-epiploic arteries, deſcending in many ſmall branches, and ſubdivided in a reticular manner: of theſe, the arteries on each ſide run to the greateſt length; but the inner or poſterior leaf of the omentum has ſmall arteries, which go out from thoſe of the colon. Branches alſo come to it from the ſplenic, duodenal, and adipoſe arteries. The omentum colicum has alſo its arteries from the colon, in the ſame manner as the ſmaller appendices (DCLX.) The arteries of the leſſer omentum come from the hepatics, alſo from the right and left coronaries of the ſtomach.

DCLXX. The nerves of the omentum are very ſmall, as being a fat and indolent body; yet it receives ſome little branches from the nerves of the eighth pair, both in the greater and in the leſſer curve of the ſtomach.

DCLXXI. The arteries of the meſentery are, in general, the ſame with thoſe that go to the inteſtines; the ſmaller branches of which go to the ſmaller glandules and cellular fat included within the meſentery. But, to the meſocolon, ſmall arteries are diſtributed on all ſides from thoſe of the various parts connected to it; as the intercoſtals, ſpermatics, lumbals of the renal capſules, and tranſverſely from the ſplenic artery, with the pancreatic branch of the duodenum: but, in the left meſocolon, there are alſo ſmall arteries detached from the aorta itſelf to the glandulæ lumbales.

DCLXXII. The veins of the omentum, in general, accompany the arteries, and unite into ſimilar trunks; thoſe of the gaſtrocolic omentum from the left ſide open into the ſplenic, as do thoſe of the hepaticogaſtric, which likewiſe ſends its blood to the trunk of the vena portarum: thoſe from the larger part of the right gaſtrocolic omentum go to the meſenteric trunk; as do thoſe of the omentum colicum, with thoſe of the appendices epiploicæ. All the veins of the meſentery meet together in one, which is truly the trunk of the vena portarum: in forming which, they are firſt collected into two large arms; of which one receives the gaſtro-epiploica, with the middle colic and iliocolic veins, and all thoſe of the ſmall inteſtines as far as the duodenum; the other arm, which goes tranſverſely acroſs the former, that ariſes above it, is embraced by the duodenum, and returns the blood of the left colic veins, with thoſe of the rectum, except the lowermoſt, which belong partly to thoſe of the bladder, and partly to the hypogaſtric branches of the pelvis. The vein which is commonly called *hæmorrhoidalis interna*, is ſometimes inſerted rather into the ſplenic than into the meſenteric vein. If it be demanded, Whether the omentum has any lymphatic veſſels? we anſwer in the affirmative: ſince there are conglobate or lymphatic glandules, both in the little omentum and in the gaſtrocolicum; alſo the ancient anatomiſts have obſerved pellucid veſſels in the omentum; and, lately, a modern has deſcribed them for lacteals of the ſtomach.

DCLXXIII. Other uſes of the omentum are, to interpoſe betwixt the inteſtines and peritonæum, which, by inflammation, are very apt to grow together; to keep the former in a ſtate of free motion, as well among themſelves as againſt the peritonæum, with but little attrition; and to anoint the muſcular and membranous fibres with a very ſoft oil. For theſe reaſons, even in inſects, there is a great deal of fat placed round the inteſtines. In the large inteſtines, there are a great many appendices, which likewiſe are produced from the large branches, and cannot altogether cover the omentum. But the ſame ſets the veſſels in order; conducts and gives them ſtrength; and exhales a ſoft vapour, which, mixed with the exhaling abdominal water, anoints and lubricates all the viſcera.

DCLXXIV. The meſentery ſerves to ſuſpend and diſplay the inteſtines in ſuch a manner, that they may move freely, and with a degree of firmneſs: it ſerves as a bed to ſuſtain, and ſafely conduct the numerous veſſels, nerves, and glandules; of which laſt we ſhall ſpeak hereafter: it alſo gives an external coat to the inteſtines, and forms moſt of the omenta.

DCLXXV. But, beſides, the blood, returning thro' the meſenteric and meſocolic veins, brings with it another principal conſtituent part of the bile; namely, a ſub-alkaline watery humour, which is abſorbed by the veins from all the ſmall inteſtines, as will be demoſtrated in its proper place. Beſides this, it gives to the liver a more putrid water from the large inteſtines, which is fetid, and nearly approaches to a volatile alkaline nature, abſorbed from the feces, that now begin to ſmell ſtrong; the exiſtence of which is eaſily proved, both from our own experiments, and the drying of the feces when too long retained. The water is, therefore, a fluid in itſelf, and rendered more ſo by an incipient putrefaction; and, conſequently, it ſerves to reduce the tenacity of the oil belonging to the omentum and meſentery, ſo as to keep it from congealing. But more eſpecially in the bile, it conſtitutes the rancid alkaline quality, with which this humour abounds; and from thence comes the great tenuity and tinging ſaponaceous quality of the bile.

CHAP. XXII.

Of the SPLEEN.

DCLXXVI. THE ſpleen itſelf is one of thoſe viſcera, which ſend their blood to the liver. It is a blueiſh, pulpy, ſomewhat oval viſcus, ſomething like a maſs of congealed blood in its conſiſtence, having frequently a notch or inciſure in its oval circumference; whence it is convex towards the ribs, concave inwardly, and circumſcribed with two margins or edges, of which the inferior and anterior is the ſharpeſt. It is connected to the ſtomach by the little omentum; and above that, by the upper ligament, ſupported by the ſubjacent colon, and by another ligament (DCLVIII.)

behind the renal capſule; to which, and to the kidneys, it adheres by the peritonæum. It alſo receives the peritonæum from the diaphragm, under the denomination of a ligament, in the back part of its hollow ſinus, behind its veſſels. The ſituation of it varies with that of the ſtomach itſelf, which it follows. When that is empty, the ſpleen is raiſed perpendicularly, ſo as to place its extremities right up and down: but when the ſtomach is full, the middle curve or arch of it ariſes upward and forward (DCXXII.); and at the ſame time obliges the ſpleen to change its ſituation, ſo as to lie almoſt tranſverſely with its lower end forward, and its upper end backward. Thus, being of a very ſoft and looſe texture, it grows larger by diſtention when the ſtomach is empty, and becomes leſs again when its blood is preſſed out by the diſtention of the full ſtomach againſt the ribs. From hence the ſpleen is found large in thoſe who die of lingering diſeaſes; but in thoſe who die ſuddenly, and in full health of body, it is ſmall. Another motion of the ſpleen is, that of deſcending with the diaphragm in inſpiration, and aſcending again in exſpiration; and beſides this, the ſpleen frequently varies in its ſituation with that of the colon. Frequently there is a ſecond or leſs ſpleen placed upon the former.

DCLXXVII. The *blood-veſſels* of the ſpleen are large, in proportion to its weight. The arterial trunk comes from the cœliac; the upper branch of which, proceeding in a ſerpentine courſe above and behind the pancreas, to which it gives branches, as well as to the meſocolon, ſtomach, and omentum, is at length incurvated in the direction of the ſulcus or notch of the ſpleen, which it, after a manner, perforates by ſeveral diſtinct branches, ſuſtained at the right extremity by the omentum gaſtrocolicum. The thickneſs of this artery is greater than that of the aorta. The ſplenic vein, which accompanies the artery, is conſiderably ſofter than any other veins of the body; it forms the principal left branch of the vena portarum. Beſides theſe, the ſpleen re-

receives ſmall arteries from the great coronary deſcending behind the pancreas, and ſometimes from the internal hæmorrhoidal. The vaſa brevia of the ſpleen and ſtomach we have mentioned elſewhere; and its ligaments and membranes receive ſmall arterial twigs from the lumbar arteries, phrenics, intercoſtals, and thoſe of the renal capſules. In like manner alſo the veins in the ſpleen, and thoſe which join it to the ſtomach, communicate with the phrenics, and with the veins of the renal capſules.

DCLXXVIII. The *lymphatic veſſels* of the ſpleen are deſcribed to ariſe in the duplicature of the ſplenic coat or membrane[156] (of which there is none at all), and from thence to proceed on to the receptacles of the chyle, very evident in a calf; in mankind they are rendered conſpicuous by blowing air under the membrane, by maceration, or water injected into the arteries.

DCLXXIX. The *nerves* of the ſpleen are very ſmall; from whence it is capable of but little pain, and is very rarely inflamed. They ariſe from a particular plexus, compoſed out of the poſterior branches of the eighth pair at the ſtomach (DCXXX.), and of certain branches from the large gangliform plexus, which produces the ſplenic trunk of the intercoſtal nerve, from whence the branches ſurround the artery into the ſpleen.

DCLXXX. The fabric of the ſpleen appears to be much more ſimple than has been commonly believed. For it is compoſed, both in us and in calves, altogether of arteries and of veins; the former of which, after ſpending themſelves in a great number of ſmall branches, are at length thickly ſubdivided into very ſoft bruſh-like bunches, very difficult to fill with injection, terminating in circles; by which there is a ready paſſage for liquors into the correſponding veins. Theſe circles, with their parallel branches, form a ſort of bunches like a pencil bruſh, but of a ſhorter rounder kind; whence many have miſtaken them for glands. Nor does the injection, rightly managed, ever eſcape from the veſſels into the intervals; nor were any hollow glandules ever diſcovered by certain obſervation. Every little arterial trunk, with the ſmaller twigs that proceed from it, are each of them ſurrounded by a very fine cellular ſubſtance or web-work, in the ſame manner with the ſmall veſſels of all the other viſcera, but here rather ſofter. The whole body of the ſpleen is outwardly ſurrounded by a ſingle membrane, which is not very tough, continued from the peritonæum, and joined to the fleſhy part of the ſpleen by a pretty thick cellular texture.

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[156] The reaſon why Haller denies this, ariſes from this error: That the proper tunic of the ſpleen comes from the peritonæum; which however is not the caſe. The ſpleen, like the kidneys, has a membrane of its own, over which a piece is continued from the peritonæum; from thence ariſes a true duplicature, containing a plexus of lymphatic veſſels.

DCLXXXI. Hence we obſerve, that the ſpleen contains more blood, in proportion, than any of the other viſcera; ſince it has no muſcles, fat, air-veſſels, or excretory ducts, interpoſed betwixt its blood-veſſels. We learn alſo from obſervation, that the blood of this part hardly ever congeals, from the abundance of its volatile or bilious ſalts: but it looks of a dark-brown colour, and may be eaſily diluted; whence one may compare it almoſt to the blood of a fœtus.

DCLXXXII. The want of an excretory duct to the ſpleen, has occaſioned the uſe of it to be doubtful, and controverted throughout all ages of anatomy. To us the fabric itſelf ſeems to lead to the following uſes; although, perhaps, they do not comprehend all the uſes of the ſpleen. A great quantity of blood is imported to the ſpleen (DCLXXVII.), and with a ſlower motion, from the ſerpentine courſe and hardneſs of the artery: but, at the time when the ſtomach is empty, this blood comes, and is received in a greater quantity by the ſpleen, not now ſo much compreſſed, therein to ſtagnate, as it would ſeem plainly from the great proportion of branches to the trunks in this part; to which add, the difficult courſe or ſlow circulation which the blood meets with in paſſing from the ſpleen through the liver: from hence the frequent ſcirrhoſities of the ſpleen;

and from hence the immenſe quantity of blood with which the ſpleen is in every point diſtended, the like of which we do not ſee in any other part. Here, then, the almoſt ſtagnant blood, fomented with heat, attenuated, and in a manner diſſolved by the putrid feces of the adjacent colon, enters thus upon the firſt ſteps of a begun putrefaction, as we learn by experiments, both from its colour and conſiſtence. But the greater fluidity of the blood herein, proceeds not only from this diſſolution, but becauſe all its watery juices that enter by the artery return alſo again by the vein; for there are no ſecretory ducts in the ſpleen.

DCLXXXIII. Moreover, when the ſtomach is full of food or flatus, the ſpleen is thereby compreſſed into a narrower compaſs, againſt the ribs and ſuperincumbent diaphragm, by which means the blood, that before was ſcarce able to creep along through the ſplenic veins, being now preſſed out more plentifully, returns with a greater celerity towards the liver; till mixing with the ſluggiſh blood in the trunk of the porta, repleniſhed with the fat or oil of the omentum and meſentery (DCLXIX.), it dilutes or thins the ſame, and renders it leſs apt to ſtagnate or congeal; and at the ſame time it conduces to form a larger ſecretion of bile at a time when it is moſt wanted, viz. to flow plentifully to the food now under digeſtion. The ſpleen, therefore, ſeems to prepare the blood, that it may ſupply a ſort of watery juice to the bile; but ſuch as is probably of a ſubalkaline nature, and rendered ſomewhat ſharp by the remora of the blood.

DCLXXXIV. Whether is the ſpleen of a cellular fabric? Is the blood poured out into thoſe cells ſo as to ſtagnate? or is it diluted with ſome juice ſecreted by peculiar glands? We ſee nothing of this is demonſtrable by anatomy; nor does the liquor or wax injected ever extravaſate into the cellular ſubſtance, unleſs urged with much greater violence than nature ever uſes or intended. As to the old queſtion, Whether the ſpleen brews up an acid to whet or ſharpen the ſtomach?

that opinion has been long diſcarded, as repugnant to the nature of all the animal juices. If it be aſked, Whether the ſpleen be not an uſeleſs maſs, as it might ſeem to be, from the little damage an animal ſuſtains after it has been cut out? we anſwer, That a robuſt animal, ſuffering but little injury from the loſs of a part, does not prove it to be uſeleſs; and yet there are examples, after ſuch an experiment has been made, that the liver becomes ſwelled and diſordered, makes a leſs quantity of bile, and of a darker brown colour; while the animal is perpetually troubled with flatulencies, gripes, or indigeſtion: all which are to be aſcribed to the vitiated nature of the bile, an obſtruction of the liver, and an imperfect or weak digeſtion; at they ſame time they are confirmed by repeated experiments.

CHAP. XXIII.

Of the PANCREAS.

DCLXXXV. THE pancreatic *juice*, which is watery, inſipid, thin, neither acid nor alkaline, is poured into the ſame place into which the bile diſcharges itſelf.

DCLXXXVI. The *pancreas* is a very long glandule, the largeſt of the ſalival kind, extended over the inferior lamina of the tranſverſe meſocolon; which, beyond the pancreas, behind its ſuperior lamina, behind the ſtomach, before the ſpleen, under and behind the liver, meets with the inferior lamina: it lies before the left capſule and the aorta; is plain, and of a triangular ſhape, with a light ſtroke on the upper part, and covered with the peritonæum, upon which the poſterior flat ſide of the empty ſtomach is ſupported; for that ſide of the ſtomach is both lower as well as poſterior. The pancreas begins ſmall from the ſpleen itſelf; and extending almoſt tranſverſely towards the right ſide, it emerges forwards to the peritonæum, acroſs the vertebræ, to the right ſide of which it grows conſiderably broad, being received betwixt the ſuperior and inferior plate of the tranſverſe meſocolon (DCLIX.); and is, finally, ſo connected by its round head to the duodenum, that this inteſtine ſerves it for a meſentery. The ſtructure of it is, like that of the ſalival glands, made up by a great number of ſmall kernels of a firm texture, connected to each other by a good deal of cellular ſubſtance. The pancreatic *blood-veſſels* are rather numerous than large, derived chiefly from the ſplenic branches: but on the right ſide it is ſupplied by the firſt artery of the duodenum, and from that other which is lower down, and is in common both to the duodenum and pancreas; both of which ariſe from the hepatic artery, and of which the former inoſculates with the latter, and both with the meſenteric artery, which ſupplies conſiderable twigs to this gland; but the ſmaller ramifications come from the phrenic and capſular arteries. The *nerves* of this gland are not of any conſiderable ſize; whence it is but little ſenſible: they are derived from the poſterior gaſtric and the hepatic plexus, from that of the ſpleen, &c.

DCLXXXVII. The *excretory duct* of this gland runs almoſt through its middle, white and tender, ariſing every where from a great number of roots; by which, being gradually increaſed, it emerges before the vena portarum and meſenteric artery, and receives a large branch from the lateral pancreatic portion; from whence it advances to the ſame part of the duodenum into which the biliary duct opens; where, changing its courſe downward, it enters through the ſinus that lies betwixt the coats of the inteſtine, internally ſmooth; and here, receiving the ductus choledochus, it opens together with that into a certain fold of the ſame duodenum, deſcending towards its loweſt part. But not unfrequently it opens diſtinct, both in its duct and orifice, from that of the biliary duct; and ſometimes it is inſerted by two ducts, of which the lower one only is diſtinct and leſs; but in man, and moſt other animals, it always opens near the duct of the bile. In its mouth there is no bile.

DCLXXXVIII. The quantity of juice ſecreted by this gland is uncertain: but it muſt be very conſiderable, if we compare the bulk or weight of it with that of the ſalival glands; than which it is three times larger, and ſeated in a warmer place. It is expelled by the force of the circulating blood, with an alternate preſſure from the incumbent and ſurrounding viſcera; as the liver, ſtomach, ſpleen, meſenteric and ſplenic arteries, with the aorta. The great uſefulneſs of this gland may appear from its being found not only in man, but almoſt in all animals: nor is its uſe the leſs from that experiment which ſhows a great part of it may be cut out from a robuſt animal without occaſioning death; becauſe, in the experiment, a part of the pancreas muſt be left with the duodenum. Its effervеſcence with the bile ariſes from the effect of a ligature, and air mixed with the inteſtinal humour.

DCLXXXVIII. The pancreatic juice ſeems principally of uſe to dilute the viſcid cyſtic juice, to mitigate its acrimony, and mix it with the food. Hence it is poured into a place remote from the cyſtic duct as often as there is no cyſtis. Like the reſt of the inteſtinal humours, this juice dilutes the maſs of aliments, reſolves them, and does every other office of the ſaliva.

CHAP. XXIV.

Of the Liver, Gall-Bladder, and Bile.

DCLXXXIX. THE *liver*, being the largeſt of all the viſcera, fills up a very large part of the abdomen in its upper chamber, above the meſocolon; and is ſtill larger in proporton in the fœtus. Above, behind, and to the right ſide, it is covered by the ſuperincumbent diaphragm, from which it receives the peritonæum for a covering, under the denomination of ligaments, chiefly in three places; for on the convex part of the liver, from the paſſage of the vena cava to the tranſverſe furrow of the liver, the peritonæum deſcends double, growing broader in the forepart, under the name of *ligamentum ſuſpenſorium*, which divides the greater right lobe from the leſſer left lobe of the liver; and then parting from its duplication, it expands into the proper coat of this viſcus (DCXXIII.), which is white, ſimple, and thin, like the external coat of the ſtomach; and under this ſpread the cellular ſubſtance, by which it is intimately conjoined with the fleſh of the liver. To the lower margin of this, joins the umbilical vein; which, in an adult, being dried up, leaves only a ſmall cord, ſurrounded with much fat. In the extremity of the left lobe, and on the convex part, not unfrequently at its edge, a membrane goes to the liver from the diaphragm; which in children, and other young ſubjects, is frequently to the left ſide of the œſophagus, but in adults to the right ſide; yet always conjoined both to the gula and to the ſpleen, whenever the liver or the left ligament is very large. The right ligament ties the diaphragm in its hinder part to the thickeſt part of the right lobe. Beſides, but without any apparent length, the membrane of the right lobe of the liver is often conjoined by the cellular ſubſtance with the diaphragm; more eſpecially in old ſubjects, for in the fœtus it is eaſily ſeparated; and then it continues it courſe betwixt the ſuſpenſory and left ligament, joined as before with the peritonæum, ſo as to reſemble a ligament. But alſo from the right kidney, the peritonæum going off to the liver, makes a reduplication like a ligament, and conjoins together the leſs omentum with the continued looſe productions of the meſocolon (DCLXIII.) with the liver, ſtomach, and duodenum; and likewiſe the ſame meſocolon to the pancreas. Thus the liver is ſuſpended in the body, with a conſiderable degree of firmneſs; yet ſo as to be allowed a conſiderable liberty to move and be variouſly agitated, raiſed, and depreſſed, by the actions of the diaphragm. The ſame ligaments form a common membrane, which covers the liver as well as other viſcera.

DCXC. Moreover, the inner concave face of the right liver lies with its forepart before the colon; and in its back part correſponds to the right kidney and renal capſule, to which it is connected by the cellular ſubſtance. The middle ſinus lies near the duodenum, which touches the gall bladder; and alſo lies contiguous with that part that conducts the great blood-veſſels. The left lobe extends largely over the ſtomach; and frequently, eſpecially in younger ſubjects, goes beyond the œſophagus into the left hypochondrium. The lobule, in the mean time, adapts itſelf to the leſſer curve of the ſtomach. But, moreover, the pancreas is covered by the liver, and the right renal capſule is tied to the part of the liver fartheſt to the right ſide by much cellular texture.

DCXCI. The figure of the liver is difficult to deſcribe. It begins in the cavity of the right hypochondrium, by a very thick ſolid protuberance, convex towards the diaphragm, and hollow towards the colon and kidney; having a protuberant line dividing the faces of theſe ſmall hollows, which is continued to the longer appendix of the lobule. After this, the liver grows ſlenderer and thinner, and is at laſt terminated or extenuated into a tip, almoſt triangular; which, paſſing into the left hypochondrium, goes before the œſophagus, in young ſubjects, as far as the ſpleen; but in adults, it is often ſhorter, and ends at the œſophagus. The edge, in which the convex part of the liver meets with the concave one, is wholly in the fore and lower part. The whole obtuſe margin lies backward. The upper and back part of the liver is every where convex; ſuſtains the diaphragm; and in a large part, which is ſomewhat flatter, towards the left ſide, it is placed under the heart: but the lower ſurface, being variouſly figured, reſts itſelf upon the duodenum, colon, ſtomach, pancreas, and right renal capſule. For there are ſeveral little furrows which divide the ſurface into different regions, and which did not eſcape the notice of the ancients.

DCXCII. The principal of theſe furrows is extended tranſverſely, from the right ſide to the left, and divides a third part of the liver, beginning ſlender in the right lobe, and growing broader towards the left. Before this tranſverſe ſulcus, there is an excavation in the right lobe for the gall-bladder, and then the anonymous convex lobule; after which comes the foſſa of the umbilical vein, extending tranſverſely backward, often covered with a proceſs or bridge that joins the anonymous to the left lobe; but behind the great ſulcus, firſt towards the right ſide, there is a ſlender tranſverſe eminence growing broader to the right, and moderately hollow, by which the great blood-veſſels are conducted into the liver: and this little valley was by the ancients denominated the *portæ* or gates of the liver. This joins the lobule, which I ſhall deſcribe, with the right lobe. Then the poſterior lobules, ſhaped like a nipple, obtuſely conical, projects into the leſs curvature of the ſtomrch. The thick root of this and the former excavated eminence, begins from the convex part of the liver, at the diaphragm; and from thence, on the right ſide, is impreſſed with an oblique furrow, inclined to the right ſide, for the paſſage of the trunk of the vena cava, deſcending from the heart to the lumbal vertebræ; and is frequently ſurrounded by a great part of the fleſh of the liver, like a bridge, or even ſo as to complete the circle, and form a tube. The left end of the lobule is terminated by another foſſa almoſt ſtraight backwards, but inclined to the left; which, taking its origin from the extremity of the tranſverſe one, terminates at the paſſage of the vena cava through the diaphragm. In this ſinus was lodged the ductus venoſus in the fœtus, of which there are ſome remains to be perceived alſo in the adult. All that lies beyond this is the left lobe, which is ſingle, equally concave below, ſo that it may lie upon the ſtomach, and is extenuated to a thin edge.

DCXCIII. This ſo large viſcus is proportionably ſupplied with veſſels, and of various kinds. The artery, which is indeed conſiderable, being the greater right portion of the cæliac, emerges from the trunk forward, and to the right, going tranſverſely before the vena portarum; and after giving off a ſmall coronary with the pancreatic and duodenal artery, the laſt of which is pretty large, it goes on and enters the liver, commonly by two branches; of which the left is betwixt the umbilical foſſa, the venal duct, poſterior lobule, with the left and the anonymous lobe, alſo the ſuſpenſory ligament; and this branch inoſculates with the phrenic and epigaſtric arteries. The right enters the liver lower, covered by the biliary ducts; and having reached the right with the anonymous lobe, there ſends off, in one ſmall trunk, the cyſtic artery, which ſoon after divides into two, and is ſpread both under and upon the gall-bladder, covered by the common coat of the liver, and ſupplies not only the gall-bladder and biliary ducts with its branches, but likewiſe ſome part of the liver itſelf. From the left branch, or ſometimes from the trunk of this, ariſes a ſuperficial artery to the biliary ducts, anonymous lobe, and glandules of the portæ. Beſides the cæliac artery, there is frequently a large right branch produced from the meſenterica major, creeping behind the pancreas; and this ſerves inſtead of the eighth branch of the hepatic artery from the cæliac. But likewiſe, the greater coronary, which is the firſt twig of the cæliac, always gives ſome ramifications to the left lobe, and to the foſſa of the ductus venoſus; which laſt branch is often very conſiderable. The leſſer arteries are thoſe ſent to the liver from the phrenic, mammaries, renal and capſular arteries. They communicate alſo with the epigaſtrics.

DCXCIV. In the fœtus, the umbilical vein brings much blood to the liver, at which time the vein ſtretching to the portæ is but ſmall. It ſends forth branches while it ſtretches backwards through its foſſa; theſe branches are numerous, and very large; ſo that one of them equals the vena portarum in bigneſs, in that place where it is dilated into a tumour, which unites with the left branch of the vena portarum. But it ſends one branch through the poſterior part of the horizontal foſſa into the vena cava, or ſome of its hepatic branches: this is called the *ductus venoſus*. In an adult perſon, indeed, this duct is filled up; and the vena portarum, which now grows larger, fills the hepatic branches.

DCXCV. The vena portarum receives all the blood of the ſtomach (DCXXIX), of the inteſtines and meſentery (DCXXXI.), of the ſpleen (DCLXXVII.), omentum (DCLXIX.), and, laſtly, of the pancreas, at firſt into two trunks, the tranſverſe ſplenic and aſcending meſenteric; then into one, which is continued with the meſenterics. This is large, compoſed of ſtrong membranes, firſt a little bent behind the duodenum, where it receives the vein from its right ſide, together with the leſſer coronary; whence going higher to the right ſide, it again divides into two large trunks in the ſinus of the lobule of the liver (DCXCII.), and immediately after is again divided into two large trunks. Of theſe two, the right, being ſhorter, larger, and bifurcated, having received the cyſtic vein, goes to its own lobe. The left runs on through the remaining part of the tranſverſe furrow of the liver; and after giving veins to the lobule, with the anonymous and left lobe, it is incurvated and enters the umbilical foſſa; from whence about the middle, it immerges and ramifies through the liver. There are ſome inſtance in which the venous branch of the poſterior lobule has been ſent diſtinct from the vena portarum.

DCXCVI. The *vena portarum* is on every ſide ſurrounded with a good deal of cellular ſubſtance, derived to it from the meſentery and ſpleen, denſe, ſhort, and adding ſtrength to the membranes; thoſe with which it is furniſhed being harder than the aorta itſelf. Intermixed with this cellular ſubſtance, are alſo many of the ſmaller veſſels and hepatic nerves, which all come together under the denomination of a *capſula*, which is nothing more than the cellular ſubſtance, and never has truly a ſingle fleſhy fibre. By this the vena portarum is conducted to the liver, and firmly ſuſtained; inſomuch, that the branches, being cut, maintain the round lights of their ſections. But each branch of this veſſel is divided into many others, again divided and ſubdivided, after the manner of arteries, till they at length produce the ſmalleſt capillaries. In this courſe every branch of the vena portarum is accompanied with a ſocial branch of the hepatic artery, creeping upon the ſurface of the vein, and the contiguous hepatic ducts, almoſt in the ſame manner as the bronchial arteries uſually creep along the ramifications of the windpipe in the lungs; while, in the mean time, both the artery and the vein are connected to the branches of the biliary ducts by a thin cellular ſubſtance like a ſpider's web. Some go out of the liver, being divided to the ligaments, and inoſculating with the ſurrounding veins. And the ſum of the branches in the vena portarum is always greater than the trunk; whence the lights of all the branches together greatly exceed that of the trunk (XXXVII.): from whence follows a great friction or reſiſtance (CLXXX and CLXII.), after the ſame manner as we obſerve in the arteries.

DCXCVII. But, ſince the blood is in this manner conveyed through the liver to the branches of the vena portarum, together with the hepatic artery, it muſt of courſe be conveyed back again by ſome other veins: and, therefore, the extreme branches of the vena portarum and hepatic artery inoſculate ultimately into other veins, which are *branches of the cava;* which ariſing from the whole circumference of the liver, run together towards the poſterior gibbous part of the liver into branches and trunks, which at laſt go off into ten or more large veſſels. The leſſer of theſe trunks, and greater number of them, paſs out through the poſterior lobule of the liver, and go to the cava through the ſulcus, that lies on the right ſide of the lobule, often completed into a circle by a ſort of bridge or production of the liver; from whence they aſcend together through the diaphragm towards the left ſide. Two or three trunks, much larger than the former, are inſerted into the ſame cava, cloſe to the diaphram, whoſe veins they often take in by the way. The branches of the vena cava are, in the adult, generally fewer and leſs than thoſe of the vena portarum; which is an argument that the blood moves quicker, becauſe of the leſs friction (CLXX.), and of the very collection of the blood into a leſs light or capacity, by which it is always accelerated when there is a ſufficient compreſſing force (CLXX.) As to any valves at the openings of theſe branches into the cava, I know not of any which deſerve to be regarded. The trunk of the vena cava, paſſing through a foramen of the diaphragm, obtuſely quadrangular, ſurrounded and terminated by mere tendons (CCLXII.), is thereby rendered not eaſily changeable: and having ſurmounted this opening of the diaphragm, it then immediately expands into the right auricle. The ſmaller veins of the liver creeping about its ſurface, are ſent forth from the phrenics, renals, and azygos; or at leaſt there is certainly a communication betwixt theſe and the hepatic veins coming from the portæ.

DCXCVIII. That the blood comes from all parts (DCXCV.) by the vena portarum to the portæ, is proved by a ligature, by which any vein betwixt theſe parts and the ligature ſwells; but the porta itſelf, above the ligature, grows flaccid and empty. But that it afterwards goes through the liver to the cava, appears by anatomical injections, which ſhow open and free anaſtomoſes or communications betwixt the vena portarum and the cava, together with the common nature of the veins going to the cava. Again, the difficult diſtribution or paſſage through the vena portarum, like to that of an artery, together with its remoteneſs from the heart, and the oily or ſluggiſh nature of the blood itſelf, occaſion it to ſtagnate, accumulate, and form ſcirrhous ſwellings in no part oftener than the liver. But this danger is diminiſhed by the motion of the adjacent muſcles, and by the reſpiration; as it is increaſed by inactivity, with ſour and viſcid aliments. But, hitherto, we have been ſpeaking of the adult liver, in which both the umbilical vein and the ductus venoſus are empty and cloſed up, although they continue to cohere with the left branch of the vena portarum.

DCXCIX. The *nerves* of the liver are rather numerous than large; hence, when wounded or inflamed, it is capable of no very great pain. They have a twofold origin[157]. Moſt of them ariſe from the large gangliform plexus, made by the ſplenic branch of the intercoſtal nerve, with the addition of a branch from the poſterior plexus of the eighth pair; they accompany the hepatic artery, and, playing round its trunk, are diſtributed with that and the portal branches throughout the liver. Another faſciculus of nerves uſually enters with the ductus venoſus, and ariſes from the poſterior plexus of the eighth pair, but ſometimes from the great plexus.

DCC. The *lymphatic veſſels* of the liver are numerous, being conſtantly and eaſily to be ſeen about the portæ. They ariſe from the whole concave ſurface of the liver and gall-bladder, and run together into a plexus, ſurrounding the vena portarum, going afterwards to the ſmall conglobate glandules, ſeated before and behind the ſaid vein; from whence they meet together in one large trunk, which is one of the roots of the thoracic duct. Upon the convex part of the liver are deſcribed other lymphatics, whoſe inſertion is not well known; but it is hardly probable that they enter the cava, nor have I been able to find that they lead to the ciſtern of the chyle.

DCCI. The interior fabric of the liver is more obſcure. Through the whole ſubſtance of the liver go bundles of biliary veſſels, of branches of the vena portarum, and of the hepatic artery. Each veſſel has both its proper cellular texture ſurrounding it, and ſimilar ligaments, by which it is tied to its fellow veſſels; and, laſtly, the whole bundle has its cellular texture placed round it. The branches of the vena cava lie on the outſide of the reſt, being leſs accurately received into the ſame bundle. Laſtly, the ultimate ſmall branches of the vena portarum, cava, and hepatic artery, together with the bilious ducts, which we ſhall ſoon deſcribe, are united together by means of the cellular ſubſtance (DCXCVI.), into a ſort of mulberry-like bunches, of an hexagonal ſhape, ſurrounded with a lax cellular texture. In theſe bunches, likewiſe there are mutual anaſtomoſes betwixt the portal branches and hepatic artery, with the roots of the vena cava on one ſide, and the firſt organs of the pori biliarii of the liver on the other ſide; which laſt demonſtrate their inoſculations by anatomical injections, for liquors injected by the vena portarum return again through the porus choledochus.

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[157] My obſervations make out three ſources of hepatic nerves; the anterior, which run to the left lobe, ariſe from the eighth pair alone of the right ſide; the poſterior come from the ganglion and plexus ſemilunaris of either ſide; of which thoſe that ariſe from the right ſide of the plexus are ſtrong and large, and conſtitute the great hepatic plexus, likewiſe called *plexus portarum*.

DCCII. Many eminent anatomiſts have taught that the forementioned bunches are hollow, having arteries and veins ſpread upon their external ſurface, and depoſite the bile into their cavity, after it has been ſecreted from the branches of the vena portarum. For this they allege arguments taken from the comparative anatomy of brutes, whoſe liver is made up of more round and definite bunches; and from thoſe diſeaſes which demonſtrate cells and round tubercles, filled with lymph, chalk, and various kinds of concreted matter. To this they might have added the thick ſluggiſh nature of the bile itſelf, by which it is related to mucus, and the analogy of the follicles of the gall-bladder.

DCCIII. But greater accuracy in anatomy will not allow any follicles into which the ſmall ſecretory veſſels open; for ſuch would intercept the courſe of anatomical injections, and give us the appearance of knots, intermediate betwixt the ſecretory veſſels and the biliary pores, which we have never yet been able to ſee: for the wax flows immediately, without any interruption or effuſion, into a cavity in a continued thread from the vena portarum into the biliary ducts. But, again, a follicular or glandular fabric is not allowable in the liver, from the great length of the biliary ducts. For all follicles depoſite their contents into ſome ſpace immediately adjacent; and are unfit to convey their ſecerned fluid to any length of courſe, as they deſtroy ſo great a part of the velocity received from the arteries. Laſtly, the very common preſſure which we muſt ſuppoſe to be on theſe bunches of kernels would ſo cruſh them, that no aſſiſtance could from thence be brought to promote the motion of the excretory ducts. Concretions and hydatids are formed in the cellular ſubſtance; and, laſtly, the bile, when firſt ſecreted, is ſufficiently fluid.

DCCIV. Again, we are perſuaded that no bile is ſeparated from the hepatic artery, becauſe the peculiar ſtructure of the vena portarum would be uſeleſs if it ſecreted nothing. Its office in ſecretion appears plainly by the continuations of its branches with the biliary ducts, in a manner more evident than that of the artery: but it appears by experiments, alſo, that the biliary ſecretion continues to be carried on after the hepatic artery is tied; add to this the largeneſs of the biliary ducts, in proportion to ſo ſmall an artery, with the peculiar nature of the blood collected in the vena portarum, ſo extremely well fitted for the formation of the bile. For we have already ſeen that it contains oil, which abounds more in the bile than in any other humour of the body; for it takes in the ſaponaceous water of the ſtomach by the abſorbing veins, together with the ſubfetid alkaleſcent vapours of the abdomen, which tranſpire through the whole ſurface of the inteſtines, ſtomach, omentum, liver, ſpleen, and meſentery, which are abſorbed again by the veins, as we know by inconteſtable experiments of anatomy; and, finally, the alkaleſcent ſemiputrid acrimonious humidity from the feces while they continue to thicken in the large inteſtines, which is taken up by the internal hæmorrhoidal veins, from whence that bitterneſs, alkaleſcent and putreſcent diſpoſition of the bile is derived. But in the blood of the he-

hepatic artery, we can find nothing peculiarly fit for the ſecretion of bile, or analogous to its nature.

DCCV. Since, therefore, the vena portarum conveys the blood ready charged with biliary matter, fit to be ſecreted in the leaſt acini (DCCIV.), and from thence there is an open free paſſage, without any intermediate follicles, from the ultimate branches of the vena portarum into the beginning roots of the biliary ducts, and that the humours driven into the vena portarum may eaſily chooſe this paſſage, the bile will be expelled from thence by the force of the blood urging behind, as well as by the auxiliary force of the diaphragm preſſing the liver againſt the reſt of the viſcera in the abdomen when very full (DCLXXXIX,) and again, contracted in exſpiration, it will be forced into the larger branches, and laſtly into two trunks of the larger biliary duct of the liver; which trunks meet together in one upon the vena portarum, in the tranſverſe foſſa of the liver, near the anonymous lobule.

DCCVI. The fabric of this duct is made up by a ſtrong nervous membrane like that of the inteſtines, over which is ſpread an external and internal cellular membrane; and is internally lined with a looſe villous tunic, elegantly reticulated, but aſperated with many ſmall pores and ſinuſes, and continued with that of the inteſtine itſelf. But there is here no muſcular fabric apparent. From experiments it appears to be endowed with a moderate degree of irritability. That it is vaſtly dilatable, is ſhewn from diſeaſes. The ſame ſeem alſo to ſhow that this duct is endowed with a very ſharp ſenſation.

DCCVII. The hepatic duct, thus formed, goes on upon the vena portarum, more to the right than the artery, towards the pancreas; and then deſcending obliquely, covered by ſome part of that gland, it goes to the lower part of the ſecond flexure of the duodenum, and is inſerted backward about ſix inches from the pylorus, through an oblique oblong ſinus made by the pancreatic duct, into which it opens by a narrow orifice.

The ſaid ſinus runs a great way through the ſecond cellular coat of the duodenum obliquely downward; then it perforates the nervous coat, and goes on again obliquely betwixt it and the villous tunic; and, laſtly, it opens into a protuberant long wrinkle of the duodenum. Thus there is almoſt the length of an inch taken up betwixt the firſt inſertion and the egreſs of this duct through the coats of the duodenum, by a ſinus which ſurrounds and receives the ductus choledochus, in ſuch a manner, that when the coats of this inteſtine are diſtended by flatus, or cloſely contracted by a more violent periſtaltic motion, the opening of the duct muſt be conſequently compreſſed or ſhut; but when the duodenum is relaxed and moderately empty, the bile then has a free exit. Any regurgitation from the duodenum is hindered by this obliquity and wrinkling of the duct, eaſily preſſed together, or cloſed and joined with a quick ſucceſſion of freſh bile deſcending perpendicularly from the liver. Nor does wind inflated into the inteſtine find any paſſage into the duct.

DCCVIII. But, in the portæ themſelves, this common duct receives another leſs canal of the ſame kind, which lies for a good way parallel with itſelf from the gall-bladder, making its inſertion in a very acute angle; and this, which is called the cyſtic duct, from its origin, is ſometimes firſt increaſed by another ſmall duct from the hepatic before its common inſertion. This duct is formed by the gall-bladder as a peculiar receptacle for the bile given to moſt animals; but is abſent in ſome, eſpecially thoſe of a ſwifter foot, and perhaps only in ſuch of theſe as are herbivorous [158]: it is placed in an excavation

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[158] Animals are for the moſt part diſpoſed into two claſſes with reſpect to the gall-bladder; ſome have it, and ſome want it; among the former the elephant is comprehended by all. Some perfectly want the gall-bladder, as the horſe, aſs: others have it lying in its proper furrow of the liver, and joined with the liver, as in man: others again have their gall-bladder ſeparate from the liver, as, according to Camper's obſervations, in the eagle, and once obſerved by me in man: and ſome ſhow a true bladder, ſhut up in the coats of the duodenum, as the elephant; which ſtructure I learned from Camper's drawing.

tion of the right lobe of the liver (DCXCII.), to the right ſide of the anonymous lobule, in ſuch a manner, that in infants or children it lies wholly within the edge of the liver, but in adults projects conſiderably beyond, lying upon the inteſtinum colon. Its ſituation is almoſt tranſverſe from the fore to the back parts; its neck aſcends a little upwards.

DCCIX. The figure of the gall-bladder is variable, but in general like that of a pear, terminated in its fore-part by an obtuſe hemiſpherical end, which is impervious, gradually diminiſhing backward; the neck or tip of this truncated cone being inflected upwards againſt itſelf once or twice, and tied together by the cellular ſubſtance belonging to it, makes then another ſmall flexure upward, and begins the cyſtic duct; which from thence goes on towards the left ſide of the hepatic duct. Within this duct there are many protuberant wrinkles, formed by the numerous cellular bridles which tie them together; and theſe wrinkles, conjunctly in the dry gall-bladder, repreſent a kind of ſpiral valve; but being altogether ſoft and alternate in a living perſon, they do not ſtop, only leſſen the courſe of the bile, as we are aſſured from experiments, by preſſing the gall-bladder, and by inflations. Beſides, it is reticulated like the gall-bladder itſelf.

DCCX. The outermoſt coat of the gall-bladder covers only its lower ſide, being the common covering of the liver itſelf ſtretched over the gall-bladder, and confining it to the liver within its proper ſinus. The ſecond coat is the cellular ſubſtance, and of a looſe texture. The third coat has ſometimes ſplendent fibres chiefly longitudinal; but ſome obliquely-interſecting each other in various directions. At other times it has none at all; ſo that we may doubt of its muſcular nature, eſpecially as the irritability of the gall-bladder is ſlow and obſcure. Next to theſe come the nervous coat, then the ſecond cellular, and laſt the vilous tunic; which are all found here as in the inteſtines, except that the laſt, in the gall-bladder, as well as in the biliary ducts, is reticulated and full of cells[159]. Within the gall-bladder, but more eſpecially about its neck and middle part, we obſerve muciferous pores[160], capable of receiving a horſe-hair; and beſides theſe, the exhaling arteries diſcharge ſome quantity of a watery humour into the cavity of the gall-bladder, as we obſerve in other cavities.

DCCXI. All animals, between their gall-bladder and liver, or between the ducts coming from both, have, beſides, ſome peculial openings in the gall-bladder, into which ſome ducts orginating from the liver, or the hepatic biliary duct, diſcharge their contents. In mankind theſe ducts have not been ſhown by any certain experiment, and the gall-bladder is eaſily looſed from the liver, without a drop of bile diſtilling either from it or from the liver. There is alſo a thin water in the bladder as often as the cyſtic duct is obſtructed.

DCCXII. The bile flows both out of the bladder and liver, according to its nature, as long as there is no impediment in its way; ſo that both ducts ſwell when that paſſage is obſtructed, and the cyſtic lies in a ſtraight line with the choledochus. Nor is it credible that all the bile ſhould be diverted into the gall-bladder before it flows into the duodenum. There is not a perpetual obſtacle which hinders the afflux, and peculiarly reſiſts the hepatic bile, and admits the cyſtic; the paſſage into the ductus choledochus is larger and ſtraighter, the ductus cyſticus much leſs than the hepatic, nor is that duct ſo well formed for receiving all the bile; the choledochus being much larger than the cyſtic duct, cannot therefore be made only for the reception of its bile. There are many animals in which the hepatic duct diſcharges its contents into the inteſtine without any communication with the cyſtic. In living animals, even when the cyſtic duct is free, the bile appears to deſcend into the duodenum with a perpetual current. That the quantity is very conſiderable, appears from the magnitude of the ſecretory organ, and the excretory duct, ſo many times larger than the ſalival ones; from diſeaſes, in which four ounces of the cyſtic bile only have flowed out duly through an ulcer of the ſide. But the hepatic bile goes into the bladder, as often as there is any obſtruction in the duodenal ſinus, from flatus or any other cauſe compreſſing the exit of the ductus choledochus. Accordingly, we find it extremely full, whenever the common biliary duct is obſtructed or compreſſed by ſome ſcirrhous tumour, whence the gall-bladder is ſometimes enlarged beyond all belief; and if the cyſtic duct be tied, it ſwells betwixt the ligature and hepatic duct; and in living animals, the hepatic bile viſibly diſtils into the wounded gall-bladder, even to the naked eye. The retrograde angle, or direction of this duct, is not repugnant to ſuch a courſe of the bile: for a very ſlight preſſure urges it from the liver into the gall-bladder; and even wind may be eaſily drove the ſame way, more eſpecially if the duodenum be firſt inflated. Nor does there ſeem to be any ſort of bile ſeparated by the gall-bladder itſelf. Whenever the cyſtic duct is obſtructed by a ſmall ſtone, or a ligature made upon it, we find nothing ſeparated into the gall-bladder more than the exhaling moiſture, and a ſmall quantity of inſipid mucus ſecreted from the follicles (DCCX.) In many animals, we meet with no appearance of any gall-bladder, when at the ſame time there is a plentiful flux of ſtrong well prepared and ſalutary bile diſcharged into their inteſtines. Again, it does not ſeem probable, that the cyſtic branch of the vena portarum can ſeparate bile into the gall-bladder; for that vein in itſelf is a mere reconductory veſſel: nor can any be ſeparated from the hepatic artery; for it muſt be vaſtly beyond probability, that ſuch a ſtrong bile as that of the gall-bladder ſhould be ſeparated from a milder blood than the more ſoft hepatic bile prepared from the blood which is moſt fit for that purpoſe (DCCIV.)

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[159] On account of the elegant net-work, which is divided into numerous greater or ſmaller cells, I think the name of *tunica reticularis* ſhould be given to this inner membrane of the gall-bladder. Nothing can be prettier than the preparation I have of this human membrane. The whole interior membrane of the gall-bladder, in the ſame manner as the ductus cyſticus, is wrinkled into alveolæ and membranous cells; ſome of which have a regular cubic figure, others are of an irregular figure, oblong, angular, and round: they likewiſe vary in ſize and capacity; in the middle of the cyſt they are larger; towards the extremity and bottom particularly crowded. That membrane which forms little ridges, is in ſome places more than two lines long, in others ſhorter. If, when all the cells and ridges are deſtroyed, you expand that membrane over an even ſurface, it becomes three or four times greater than the cyſt. An elegant net-work of innumerable veſſels runs upon theſe little ridges.

[160] Upon comparing Camper's drawing of the elephant's cyſt with the trials I made upon man, I am fully perſuaded, that the great number of pores, opening into the inner ſurface of the cyſt, pour out a peculiar liquid, which is neceſſary to the preparation of the cyſtic bile; but of unknown uſe.

DCCXII. Laſtly, the bile flows alſo from the gall-bladder to the liver, and at length returns into the blood when its paſſage into the inteſtines is totally intercepted, ſometimes alſo from a cauſe latent in the nerves. This paſſage or abſorption of the bile into the ſyſtem is pernicious, and is the occaſion of jaundice; which, when the offending ſtones or concretions are removed, is cured by the bile's free courſe into the duodenum being reſtored.

DCCXIII. Therefore a portion of the hepatic bile being received into the gall bladder, there ſtagnates, only a little ſhaken by reſpiration; and there, by degrees, exhales its thinner parts, which, as we ſee, filtrate thro' and largely penetrate the adjacent membranes. The remainder, as being a fluid of an oily ſubalkaline nature, digeſting in a warm place, grows ſharp, rancid, more thick, bitter, and of a higher colour: for this is all the difference betwixt the cyſtic and hepatic bile; which laſt we find weaker, leſs bitter, lighter coloured, and of a thinner conſiſtence, while it remains within its proper hepatic ducts. That this difference betwixt them proceeds only from ſtagnation, appears from ſuch animals as have only a larger porus hepaticus, inſtead of a gall-bladder; for here we find the bile, which ſtagnates in the larger hepatic pore, is conſiderably more bitter than that in the ſmaller pores of the liver; as for example,

ample, in the elephant. But the gall-bladder gives this particular advantage, that it receives the bile when the ſtomach, being empty, has no call for it, that afterwards it may be able to return it in greater plenty, when we principally want it for the digeſtion of the aliments now flowing in great quantity into the duodenum. This flow of the bile is quicker in proportion through the cyſtic duct, as the ſection of that duct is leſs than the ſection of the gall-bladder.

DCCXIV. The gall-bladder, indeed, hardly touches the ſtomach, but the beginning of the deſcending duodenum. But when the ſtomach is extremely diſtended, and in a very full abdomen, it makes a conſiderable preſſure both upon the liver and duodenum; by which the gall-bladder is urged, and its bile expreſſed. Thus the bile flows through a free paſſage, from the gall-bladder into the common duct, and the duodenum: and this it does more eaſily in perſons lying on their back; in which poſture the gall-bladder is inverted, with its bottom upward. Hence it is that the gall-bladder becomes ſo full and turgid after faſting. The expulſive force of the bile is but little more than that of the preſſure received from the ſtomach and diaphragm; for as to any muſcular force reſiding in the fibres of the proper membrane, which may be thought to contract the gall-bladder, it muſt be very weak and inconſiderable.

DCCXV. The hepatic bile is always bitter, but the cyſtic is more ſo; always viſcid; of a full yellow colour, with a tincture of green; miſcible, by triture, either with water, oil, or vinous ſpirits; coagulable by mineral acid liquors; diſſoluble by alkalies, eſpecially the volatile kinds; and extremely well adapted to diſſolve oily, reſinous, or gummy ſubſtances; quickly putrefying, and by putrefaction ſpontaneouſly degenerating to a muſk-like odour. Its chemical analyſis[161], and experiments of mixture with various ſubſtances demonſtrate, that it contains a large portion of water, and a conſiderable quantity of inflammable oil, which, in ſtones of a gall bladder, appears very evidently. The bile, therefore, is a natural ſoap; but of that ſort which is made from a volatile ſaline lixivium, mixed with oil, and has its water along with it. This, therefore, being intermixed with the aliment, reduced to a pulp, and ſlowly expreſſed from the ſtomach by the periſtaltic force of the duodenum and preſſure of the abdominal muſcles, incorporates them all together; and the acid or aceſcent qualities of the food are in ſome meaſure thus ſubdued, the curd of milk is again diſſolved by it into a liquid, and the whole maſs of aliment inclined more to a putrid alkaleſcent diſpoſition: it diſſolves the oily matters, ſo that they may freely incorporate with the watery parts, and make up an uniform maſs of chyle to enter the lacteals; the ſurrounding mucus in the inteſtines is hereby abſterged and attenuated, and their periſtaltic motion is excited by its acrimony; all which offices are confirmed, by obſerving the contrary effects from a want or defect of the bile. Nor is the hepatic bile ſufficient to excite the neceſſary motion of the inteſtines, if the cyſtic is wanting; both which are of ſo much uſe and importance to the animal, that we find, by experiment, even the ſtrongeſt will periſh in a few days, if the flux of bile to the inteſtines be intercepted, by wounding the gall-bladder.

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[161] The chemical examination, which long ago ought to have been carried on, of all the animal humours, has been begun in this age by the inveſtigation of the bile's properties: For ſince from our theory

DCCXVI. Thus it ſlowly deſcends along with the alimentary maſs; and having ſpent its force, or changed

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theory of digeſtion not only good and wholeſome bile is required, but ſo many depravities of this humour occur in diſeaſes which come under medicine, it would be of much importance, we ſee then, to know the conſtituent parts of it; by which means we certainly could preſerve the bile in its wholeſome, and correct it in its vitiated, ſtate. Since the experiments of Pringle, Ramſay, and Schroeder, much has been added on this head by the moſt celebrated perſons; Gaber, an anonymous writer's eſſay upon putrefaction, Cadet, Spielman, ten Haaff, M'Lurg, and others.

its bitterneſs by putrefaction, moſt of it is afterwards excluded together with the feces; but probably ſome of the more ſubtle, watery, and leſs bitter parts, are again taken up by the vena portarum. It returns the leſs into the ſtomach, becauſe of the aſcent of the duodenum, which goes under the ſtomach, with the reſiſtance it meets with from the valvula pylori, and the advancement of the new chyle which the ſtomach adds to the former: in man, however, it frequently enters; and always in birds. The bile is of a ſweet ſoft nature in the fœtus; for in them the feces are not very fetid to ſupply putrid alkaline vapours to the liver, nor are there any oily or fat ſubſtances abſorbed from the inteſtines. As the bile is a viſcid fluid, and thickens by inactivity of body in fat animals, and in us from the ſame cauſes, eſpecially when the blood moves languid from grief; ſo it eaſily coagulates into an hard, ſomewhat reſinous, and often ſtony ſubſtance, inſomuch that ſtones of the gall are much more frequent than thoſe of the urinary bladder, as we are taught by our own experiments. Its uſe is manifeſt, as, being triturated with the aliments, it diſſolves oil, reſiſts acidity, and thus ſtimulates the inteſtines to contraction.

DCCXVII. The uſe of the liver, beſides ſecreting the bile, is manifeſt in the fœtus. It ſeems to tranſmit the blood brought back from the placenta, and to break its force. Even in an adult perſon it has the ſame uſe though leſs manifeſt, namely, to retard the return of the blood coming back from the viſcera appointed for preparing the chyle.

CHAP. XXV.

Of the Small INTESTINES.

DCCXVIII. BY the *ſmall inteſtines*, anatomiſts underſtand one continued almoſt cylindrical tube, but whoſe tranſverſe ſection is nearly oval, the obtuſe end being towards the unconnected ſide of the inteſtine. This tube is continued from the end of the ſtomach, the right orifice of which it embraces (DCXXV.); and, being produced through a long tract, ends by an expanſion into a much larger inteſtine. Anatomiſts have uſually reckoned three ſmall inteſtines, though nature has formed but one. However, the duodenum has generally pretty certain bounds, terminating with its end in that part of the abdomen which is above the tranſverſe meſocolon (DCLIX.) But that ſmall inteſtine which lies below this meſocolon, commonly called the *jejunum*, has no certain mark or boundary to ſeparate it from the lower portion, which is commonly called the *ileum:* although the former, abounding more with valves and blood-veſſels, has, in general, a more florid appearance, and is furniſhed with longer villi internally; and the ileum again, having fewer of thoſe vaſcular ramifications, like little trees, abounds more with a ſort of minute glandules: however, theſe differences inſenſibly diſappear one in another, without affording any certain limits betwixt the two inteſtines; they are great in the extreme terminations, but obſcure in the neighbouring parts.

DCCXIX. The *duodenum* ſeems to be denominated from its length. It is larger, and more lax or open, than the other ſmall inteſtines, more eſpecially in its firſt flexures; which is partly owing to its not being circumſcribed in ſome places with any external membrane, and in other places only for a ſmall compaſs. It is florid and tender, having its fleſhy fibres ſometimes of a conſiderable thickneſs. Its origination begins round the ring-like valve at the mouth of the pylorus; from whence being undulated or inflected, but generally in a tranſverſe courſe, to the right downward and backward in an empty ſtomach, it goes under the gall-bladder, to the neck of which it is contiguous (DCCXIV.) From thence it deſcends obliquely and backwards to the right ſide as far as the lower plate of the meſocolon, where it is perforated by the biliary duct, and in that courſe is intercepted betwixt the upper and lower plate of the meſocolon. From thence at laſt it proceeds tranſverſely, but a little aſcending behind the pancreas and large meſenteric veſſels, and goes on to the left ſide along with the left renal vein, where, going out from the duplicature of the meſocolon, and bending round before and to the right of the ſaid veſſels, it paſſes through a peculiar foramen, in which the meſentery and left part of the tranſverſe meſocolon adhere to the inteſtine itſelf; from thence it deſcends forward, towards the lower part of the abdomen, into which it advances under the denomination of the *jejunum*. The largeneſs of this inteſtine, with its aſcent from the inſertion of the biliary duct, joined with the conſequent fold about the root of the meſentery, cauſe a remora of its contents, by which the bile, pancreatic juice, and alimentary pulp, are here firſt intimately blended together.

DCCXX. The reſt of the ſmall inteſtine, having no certain ſeat or diviſion, is continued by innumerable and uncertain convolutions, not to be deſcribed, ſo as to fill up the lower part of the abdomen and pelvis ſurrounded by the colon on each ſide, and lies between the bladder and uterus below.

DCCXXI. The fabric of the ſmall inteſtine is almoſt the ſame with that of the ſtomach and œſophagus. Its external coat, excepting part of the duodenum, is received from the peritonæum or meſentery, applied on each ſide to the obtuſe end of the oval inteſtine, and ſeparated by the intervening cellular ſubſtance, which is often repleniſhed with fat, but more cloſely embraces or adheres to the muſcular fibres in the unconnected ſide of the inteſtine; where the outer and muſcular coats ſtrictly cohere, without ſhowing any remarkable difference from what we have obſerved of them in the ſtomach. By this external membrane, and by the meſentery (DCLXI), the inteſtines are ſupported with a conſiderable degree of firmneſs, at the ſame time that they are allowed every way a free liberty for motion.

DCCXXII. But the fabric of the *muſcular coat* differs from that of the ſtomach, in the figure of its fibres. The largeſt and moſt conſiderable body of theſe fibres is circular, cloathing the tube on each ſide, reſembling each other both in their parallel diſpoſition and appearance, which is that of imperfect arches or ſegments of circles, cemented one to another, paler than other muſcular fibres, and yet remarkably contractile. The longitudinal fibres are, in the ſmall inteſtines, much fewer in number, ſcattered round their whole extent, interſperſed with the former, and are more eſpecially ſpread upon the looſe or unconnected ſide of the inteſtine.

DCCXXIII. Within the muſcular coat, is ſeated the *ſecond cellular tunic*, of a larger extent here, as it was in the ſtomach; and this being ſpread on all ſides round the nervous coat, which it includes, is, in us, ſeldom repleniſhed with fat. But the *nervous* coat, being like that of the ſtomach, ſerves as an internal foundation or ſupport to the whole inteſtinal tube; being compoſed chiefly of compacted fibres, which, by inflation, may be parted one from another, ſo as to reſemble a web-like or cellular ſubſtance. Next to this, follows the *third cellular* coat, which is almoſt like the ſecond; and then the innermoſt or *villous* coat, which differs, in ſeveral reſpects, from that which we deſcribed in the ſtomach: for firſt it is folded on all ſides into wrinkles that are ſemicircular, the extremities of which correſpond one to another oppoſitely, but uncertain in their proportions; into which wrinkles the nervous coat ſlightly enters, whilſt the reſt of the intermediate ſpace betwixt the folds of the villous tunic is filled up by the third cellular ſtratum. Theſe *plicæ* or folds of the inteſtine begin within one inch of the pylorus, and are moſt numerous in the firſt and middle part of the inteſtines, but gradually grow fewer in number downward. Here each ſmall twig of the artery, which is ſpread in the cellular ſubſtance, upon the convexity of the inteſtine on one ſide, is anſwered by another twig, diſpoſed in the ſame manner, on the oppoſite ſide. The plicæ are, at firſt, confuſed in the duodenum, and afterwards become more conſpicuous as the inteſtine advances; but the appearance of acute imperfect circles or valves is given to them by anatomical preparation, in which their natural ſtate is altered. They are indeed ſoft, and eaſily inverted, ſo as to give way, in any direction, to the courſe of the alimentary pulp; upon which, however, their number has ſufficient influence to retard the motion, while, at the ſame time, they enlarge the ſurface of the villous membrane.

DCCXXIV. We come now to the true villous coat, which we call ſo in other parts by analogy. Namely, the whole internal ſurface of the inteſtine and its valves, together with the ſmall cavities interpoſed betwixt them, ſend out on all ſides innumerable ſmall fluctuating fleeces like a piece of velvet, the extremities of which are obtuſely conical productions of the inner coat of the inteſtine, and from the cellular ſubſtance, intercepted between the duplicature, and from the ſmall veſſels and nerves wrapped up in that celluloſity, and likewiſe from the lacteal veſſel which we ſhall afterwards ſpeak of, ſo as very much to reſemble the papillæ of the tongue, only of a ſofter texture.

DCCXXV. The chief ſmall veſſel of each villoſity is an oval veſſel opening by a ſlender duct in the ſurface of the villous coat, often filled with milk, which the neighbouring ſmall veſſels every where ſurround.

DCCXXVI. In the internal ſurface of this villous coat, open an infinite number of pores; ſome *larger*, other ſmaller. The former lead to ſmall conſpicuous ſimple glandules of the mucous kind, ſeated in the ſecond cellular ſtratum, and like to thoſe of the vaſcular follicles ſeated in the mouth and pharynx, which likewiſe open with numerous patulent orifices into the inteſtines. In the duodenum theſe are aſſembled together in ſeveral places, without running together; nor can they always be demonſtrated; but many of them are quite ſolitary or aſunder in the ileum, or often aſſembled only a few together; though, in many places, a conſiderable number of the ſame kind are aſſembled together, into a little army of an elliptical figure. They have every where a villous membrane.

DCCXXVII. Throughout the whole tract of the inteſtines are found *pores* of a *leſs kind* ſurrounding the baſis of the villi, and moſt ample or conſpicuous in the large inteſtines, where they were firſt obſerved; but have been lately diſcovered, by a more careful inquiry, in the ſmall inteſtines likewiſe. Theſe alſo ſeem to depoſite a liquor of the mucous kind.

DCCXXVIII. The *veſſels* of the ſmall inteſtines are very numerous. The common larger trunk belonging to the inteſtine that occupies the ſpace below the meſocolon is called the *meſenteric artery*, being the largeſt of thoſe produced by the aorta above the renal arteries. This, deſcending behind the pancreas to the right ſide of the jejunum, and before the colic branches, ſends out more eſpecially a long trunk to the bottom of the meſentery and termination of the ileum towards the right ſide; as on the left ſide it ſends out numerous branches, the firſt and laſt being ſhorter, the middle ones longeſt. Theſe laſt, ſubdividing into ſmaller, join with thoſe in their neighbourhood in ſhape of convex arches; which again ſend out other branches united in like manner, to the repetition of almoſt the fifth ſeries of arches, until the laſt ſend ſtraight and very numerous branches to the inteſtine; where, forming their laſt convexity, their numerous ſmall branches are detached on each ſide the inteſtine.

DCCXXIX. The diviſion of theſe branches in the inteſtine, is much after the ſame regular manner; ſo that one comes out from the meſentery, through the cellular ſubſtance, on the foreſide of the inteſtine, as the other does, in the like manner, upon the lower ſide; which, having given ſmall branches to the outermoſt and fleſhy coat, come to the ſecond cellular one: there the anterior trunk, running out towards the obtuſe vertex of the inteſtinal ellipſis, is continued ſtraight into the poſterior branch ſimilar to itſelf; and, according to its ſize, gradually ſends off ſmaller ſhrub-like twigs, inoſcuculating with each other, and with their oppoſites, by innumerable circles. From this arterial net-work, ſmaller twigs penetrate from the nervous tunic into the third cellular ſtratum, and are, with that, continued to the ultimate extremities of the villi, where they at laſt open by exhaling orifices, and diſcharge a watery humour into the inteſtine; for this continued courſe is eaſily imitated and ſhown, by injecting water, fiſh-glue, or mercury. But late induſtry has diſcovered, that theſe arterial extremities firſt open into an hollow veſicle; from whence their depoſited juice flows out through one common orifice. For the reſt, the arteries in this part form numerous reticular inoſculations, that, by avoiding all obſtructions, they may be able to ſupply the inteſtines equally on all ſides; and that any obſtructing matter may, upon occaſion, be eaſily removed back from the narrower extremities to the larger arterial trunks.

DCXXX. The laſt trunk of the meſenteric artery inoſculates with the ileo-colic. The duodenum has various arteries. The firſt and uppermoſt from the right hepatic goes round to the convexity of the inflexure of this inteſtine, which it ſupplies in its way to the pancreas, and inoſculates together with the lower or left pancreatico-duodenal artery, which makes a like arch round the curvature of the duodenum into the pancreas; being at laſt inſerted into the lower duodenal arteries, produced by the meſenteric in its paſſage before this inteſtine. As to the ſmall arteries which go from the ſpermatics to the duodenum, and from thoſe of the renal capſule, we deſignedly omit any further notice of them.

DCCXXXI. The meſenteric *veins* meet all together, in the ſame courſe or diſpoſition with the arteries, in the meſenteric trunk of the vena portarum; except the right duodenal vein, which goes immediately into the trunk of the vena portarum itſelf; and except thoſe ſmall veins which run in company with the ſmall arteries (DCCXXX.), and are inſerted into the ſpermatics and lumbals. Nor have I been able to diſcover any other veins of the meſentery ariſing from the cava. It is a property in common to all theſe veins to be without valves, and to make free communications with the arteries. Thoſe veins in the villous coat, which is for the moſt part compoſed of veins, abſorb thin humours from the inteſtine; as appears from the injection of watery liquors, which readily run through the ſame way; and, from analogy, in aged perſons, in whom the meſenteric glands, and conſequently the lacteals that paſs through them, are frequently cloſed up; add to this, that birds have no lacteal veſſels, and the celerity with which watery liquors paſs to the blood and through the kidneys, compared with the ſmallneſs of the thoracic duct, chiefly from thoſe experiments which have confirmed by ocular demonſtration the paſſage of water from the cavity of the inteſtine into the vena portarum.

DCCXXXII. The *nerves*, though ſmall, are numerous, whence the inteſtines receive no little degree of ſenſibility; they ariſe from the middle plexus of the ſplenic nerves, and, embracing the meſenteric artery, play round it in great numbers, wrapped up in a very denſe cellular plate. The duodenum has likewiſe ſmall nerves from the poſterior hepatic plexus of the eighth pair. From this great ſenſibility of the inteſtines it is probable, that the ultimate branches of the nerves penetrate into the third cellular coat.

DCCXXXIII. From the exhaling arteries diſtils a thin watery liquor into the cavity of the inteſtines, like the juice of the ſtomach, not acrid, but ſaltiſh. The quantity of this liquor may be computed from the large extent or ſum of all the excretory orifices, and from the ſection or light of the ſecretory artery, larger than which we ſee no where in the body; add to this, the laxity of the parts perpetually kept warm and moiſt, and the copious diarrhœa or watery diſcharge that often follows the uſe of purgative medicines. But the mucus ariſing from the pores or cells before-mentioned (DCCXXVI. (DCCXXVII.) ſerves to lubricate and defend the internal ſurface of the villous membrane, and to guard the ſenſible nerves from ſtrongly acrid or pungent particles. Hence we ſee, it is more abundant at the beginning of the larger inteſtines, becauſe there the maſs of aliment begins to be more feculent, acrid, and tenacious.

DCCXXXIV. The mixture of this liquor with the pulp-like maſs of the aliment, together with the bile and pancreatic juice, is made by the motion of the ſurrounding muſcles of the abdomen; but this force is quite ſmall, and unfit for moving forward the aliments. But for this purpoſe ſerves eſpecially the periſtaltic motion, which is more particularly ſtrong and evident in the ſmall inteſtines [162]. For any part of the inteſtine, irritated by flatus or any ſharp or rough body, contracts itſelf, even after death, moſt violently in that part where the ſtimulus is applied, in order to free itſelf from the offending or diſtending body, which it expels into the next open part of the lax inteſtine; where, being received, it is again propelled forward, by exciting a like ſtimulus and contraction as before. This contracting motion of the inteſtines is made in various parts of the gut, either ſucceſſively or at the ſame time, wherever the flatus or aliment excite a ſtimulus; and this, without obſerving any certain order. So well fitted, however, are the inteſtines for this motion, that they emulate, and even exceed, the irritability of the heart, or at leaſt are ſcarcely exceeded by it. When they are not irritated, they remain at reſt, as I have often obſerved; and we may ſuppoſe this to be the cauſe why the fat remains in the belly. The air acts chiefly as a ſtimulus to the inteſtines[163], next to it is the aliment, and laſtly the bile.

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[162] The road for our food through the primæ viæ begins in the mouth after deglutition; the meat proceeds through the inteſtinal canal by means of a periſtaltic motion, and at laſt is excreted. The beginning and end of this action, viz. the buſineſs of deglutition and ſome part of the alvine excretion, depends upon the will of the animal: the motion of the œſophagus, ſtomach, and inteſtines, can neither be increaſed nor retarded in any way by our inclination.

[163] To theſe are added in a diſeaſed ſtate external cold, joined with humidity, affecting the abdomen and feet, and evacuants of any kind.

This motion is performed by a wonderful ſort of alternate creeping and revolution of the inteſtines, which diſſection eaſily demonſtrates in living brute animals, and unhappy caſes of wounds in the abdomen and ruptures have manifeſted in the human ſpecies. And ſince here, among ſo many inflexions, the weight of the aliment is but of little force, it eaſily aſcends or deſcends through the irritated inteſtine, which thus empties itſelf. From hence the antiperiſtaltic motion is intelligible, by which the pulp of the alimentary maſs is oftener or longer applied with a gentle force to the triture of the inteſtine, to the exhaling diluent liquor, and to the mouths of the abſorbing veins. But all the contents of the inteſtine are determined downward to the large inteſtines, becauſe the ſtimulus begins above, from the left opening of the ſtomach; and ſo, by the ſucceſſion of new chyle, repeating the ſtimulus above the contraction, it deſcends, when there is no reſiſtance made to it, into the lower part of the ileum, at its opening into the colon: here the looſe part of this inteſtine readily receives what is preſſed into it by the contraction from above, and as eaſily unloads itſelf into the large unactive cæcum; from whence it is again repelled upward, and in part urged on by the preſſure of the ſucceeding maſs. Anatomiſts obſerve, that this motion is made ſtronger downward than upward, and that the ſuperior parts of the inteſtines are more irritable than the lower. But as often as an inſuperable obſtacle reſiſts the paſſage of the aliment, there will be the ſeat of the principal contraction, and the aliment likewiſe is driven upward from the valve of the colon through the whole length of the inteſtines, into the ſtomach, and laſtly into the mouth.

DCCXXXV. This periſtaltic motion of the inteſtines is performed by the conſtriction of their circular fibres, which know how to empty the tube exactly, without injuring the inteſtine againſt pins, needles, or any other ſharp bodies lodged within their contents, which they tenderly promote forward. But the revolutions of the in-

inteſtines, drawn upward and downward, and the ſtraightening of crooked parts of them one before another, which is ſo remarkably conſpicuous in brute animals, are performed by the long fibres, which we ſee contract themſelves at the ſeat of the preſent ſtimulus, and dilate the following portion of them to receive what enſues. By the ſame contraction the villous membrane of the inteſtines, within their cavity, is urged and reduced into longer folds; whence the mucus is expreſſed and applied to that part of the alimentary maſs, where it was required by the force of irritation and ſtimulus. Theſe long fibres frequently make intro-ſuſceptions of the inteſtines, and generally without any bad conſequences, by drawing up the contracted portion of the inteſtine into that which is looſe, in ſuch a manner, that the former is ſurrounded by the latter, which is relaxed.

DCCXXXVI. The alimentary pulp, therefore, diluted with the pancreatic juice and that of the inteſtines, intimately mixed with the ſaponaceous bile and circumjacent mucus, is more perfectly diſſolved than by the efficacy of the ſtomach, in proportion as the ſides of the inteſtines come into a larger contact, and approach nearer together; to which add, the longer ſeries of the periſtaltic motions, and the greater quantity of diſſolving juices. In this manner, the alimentary pulp, intermixed with air, forms a froth, without any kind of fermentation, which air is the ſame with what we commonly eructate from the ſtomach; but yet, at the ſame time, the acid or aceſcent force is ſubdued, while the oily or fat parts, diſſolved by the bile (DCCXV.), intermix with the watery juices, and give the chyle its uſual milky appearance, like an emulſion, of a bright colour in the duodenum, at the firſt entrace of the biliary duct; from whence downward it cloſely adheres to the villous coat of the ſmall inteſtines. But the gelatinous juices of fleſh meats, diluted with a large portion of water, and likewiſe from their own ſubviſcid nature, do more particularly adhere to the villous coat, and enter it in the way of abſorption. So water and watery liquors are all very greedily drank up by the veins: and yet the feculent remains never grow thick in the ſmall inteſtines, as far as I have been able to obſerve, becauſe the watery part is repaired by the arterial vapour and mucus; nor do they become fetid in any conſiderable degree, as well becauſe of the great quantity of diluting juices, as becauſe the quick progreſſion will not allow them time enough for a putrefaction. Thoſe remains, which are of a more earthy, groſs, and acrid diſpoſition, which were excluded by the mouths of the abſorbing lacteal orifices, do, by their weight, or by the muſcular contractions, deſcend ſlowly into the large inteſtines, ſo as to complete their whole courſe in the ſpace of about twenty-four hours. But within three, four, or a few more hours time, all the chyle of the aliment is commonly extracted.

DCCXXXVII. The conſiderable length of the ſmall inteſtine, which is five or more times longer than that of the body, the great ſurface of the villous membrane increaſed by folds, the incredible number of exhaling or abſorbing veſſels, the ſlow courſe of what remains through the large inteſtines, and the great quantity of the inteſtinal juice poured into the alimentary maſs, do all of them concur, in the ſmall inteſtine, abundantly to perform what is required in the emulſions of the food for our healthy juices, and for their abſorption into the lacteals and the meſenteric veins: alſo for abſterſion of viſcidities from the inteſtine; for the avoiding adheſions and coagulations; for the deſtruction of any acid diſpoſition not yet ſubdued; and for the ſubduing any venomous quality in many juices, which, being directly mixed with the blood, inſtantly kill, but are thus ſent in by the mouth without damage. Hence, in general, the inteſtines are long in animals that feed upon any hard diet, but ſhorter in carnivorous ones, and ſhorteſt in all thoſe that live upon juices: and, even in man, an uncommon ſhortneſs of the inteſtines has been known to be attended with hunger, and a flux or diſcharge of fetid and fluid feces.

DCCXXXVIII. The heat by which the aliment is fomented, and which is exceedingly proper for the ſolution of the gelatinous matter, and exciting a beginning putrefaction, is hence the principal cauſe of the fetor which is gradually produced in the aliment; thence alſo is the cauſe of that thinneſs by which the uſeful part of the aliment is fitted for abſorption. But the air alſo, incloſed in the viſcid aliment, operates here, as in the ſtomach, by breaking the coheſion of the aliments, if any yet remain whole. The inteſtinal water dilutes the little maſſes of aliment; and if any hard part remains, this liquor ſoftens it by maceration. The bile being intimately mixed with oil, diſſolves the ſame, and renders it miſcible with water.

CHAP. XXVI.

Of the Large INTESTINES.

DCCXXXIX. WHAT remains, after the chyle has been abſtracted, conſiſts of ſome portion of the bile, but mucilaginous and degenerate; ſome part of the human mucilages; moſt of the earthy parts that were lodged in the food; and all thoſe parts which by their acrimony were rejected by the abſorbing mouths of the lacteals, yet changed by means of putrefaction (DCCXXXVI.); with all the ſolid fibres and membranes, whoſe coheſion was too great to be overcome by the maceration and periſtaltic motion in the inteſtines.

DCCXL. All theſe remains paſs from the extremity of the ileum into the cæcum, in which they are collected and ſtagnate; namely, the extremity of the ſmall inteſtine, called the *ileum*, applies itſelf obliquely, in ſuch a manner, to the right ſide of the colon, reſting upon the right ileum and its muſcle, that, in general, it aſcends in a curve, but more in its lower ſide, and leſs in its upper, which is almoſt tranſverſe. But finally, the nervous and villous parts of the ileum are ſo extended betwixt the departing fibres of the muſcular and nervous coat of the colon, as to hang pendulous within the cavity of this large inteſtine, with a double eminent wrinkle or ſoft fold, compoſed of the villous and nervous coat of the thick inteſtine, and of the ſmall inteſtine likewiſe, and of the interpoſed fleſhy fibres of the ileum and colon, joined together by a good deal of the cellular ſubſtance. The upper tranſverſe fold is ſhorter, as the lower is broader and more aſcending, being conjoined by a ſmall production of the ſame kind, more eſpecially in the right ſide, adjacent to them. Betwixt theſe two folds, the mouth of the ileum opens, like a tranſverſe ſlit. But when this inteſtine is inflated, the ſtructure of it changes very much, repreſenting theſe parts to us under the figure of membranes and hard valves. After the cellular plate has been entirely removed from them, the ileum comes clean out from the colon, and the valvular appearance is no more to be ſeen; but if a large part of it only be drawn out, leaving a ſmall portion inſerted behind, it reſembles a ſphincter.

DCCXLI. Below the entrance of the ileum, at the diſtance of ſome inches, the great inteſtine deſcends and forms a blind or impervious extremity, called the *cæcum*, reſting upon the ileum. From the lower part of this, towards the right ſide, extends a ſmall worm-like proceſs, in adults of conſiderable length, like a long extended cone or little inteſtine, variouſly incurvated, ſometimes downward, and full of ſmall mucous glands, which pour out a gluey mucilage to the feces; but, in the fœtus, the colon itſelf is extended into a conical *appendix*. But the weight of the ſuperincumbent feces, depreſſing the ſpace on the right ſide of the appendix, the ſtrength of the cellular texture uniting the left part of the cæcum with the ileum; of the fleſhy fibres uniting both inteſtines; the very contractile force of the ligaments; the fitneſs of the anterior ſac of the cæcum, which eaſily receives the feces from the inteſtinum ileum; all contribute to remove the appendix from the middle, and make it to go out from the left extremity of the colon: and thus is produced the thick and pendulous globe of the colon lying fartheſt to the right ſide, and which is proper to adult perſons. When, therefore, the remains of the alimentary maſs are ſent from the ileum into the colon, they fall by their weight firſt into the cavity of the cæcum, or impervious bag-like appendix: here, by ſtagnating, and the warmth of the parts, they begin to putrefy, according to their particular nature; and here, eſpecially, the fetid ſmell, obſervable in the excrements, begins.

DCCXLII. The *colon* is an inteſtine altogether continuous, as one and the ſame with the cæcum; namely, the largeſt of the great inteſtines, and by much the ſtrongeſt. Beginning upon the ileum (DCCXL.), it aſcends over the right kidney, and lies under the liver, with an angle in the right hypochondrium; being connected to the viſcera, on each ſide, by the peritonæum. From thence it paſſes under the liver and ſtomach, for the moſt part tranſverſely, to the ſpleen, under which it ſtretches (DCLXXVI.), and in the deep receſs under the left ribs is often twiſted upon itſelf. From thence, again, continuing its deſcent to the left ileum, it forms a large flexure (DCLVIII.); from which flexure it is continued, in its lower part, through the pelvis, under the denomination of *rectum*.

DCCXLIII. The ſtructure of the colon is in general the ſame with that of the ſmall inteſtines, but it has ſeveral things peculiarly differing from them. And firſt, all the longitudinal fibres are collected together into three bundles which run through the whole extent of the inteſtine; and of theſe one, and that the largeſt, lies naked; the other ariſes from the omentum; and the third is contained in the meſocolon. Theſe are ſhorter than the inteſtine, and contract it ſo that the nervous and villous membrane (DCCXLIV.) protuberates inwardly. Theſe fibres are connected moſt accurately with the external coat of the inteſtines; but in the intermediate places, and chiefly at the meſocolon, is ſeated the firſt cellular ſtratum repleniſhed with fat. At firſt, being dilated, they adhere to the vermiform appendage. In the extremity of the colon there are often only two ligaments, where the two leſſer join into one. They diffuſe themſelves upon the r·ctum in ſuch a manner as to occupy the whole.

DCCXLIV. Again, the fleſhy and nervous coat, and third cellular ſtratum, with the villous tunic of the colon, are extended into much larger wrinkles in the parts betwixt the ligaments, often projecting in a threefold rank, ſuſtained by the ligaments, that they may be able to reſiſt and ſupport any ſhock or preſſure from the motion of the feces. In the beginning of the colon, they obſerve their three-fold order, exactly enough, at regular diſtances; but in their progreſs they vary more by degrees, being leſs, ſometimes double, often ſolitary, ſmall and large intermixed, or none at all. Where the ligaments which contract the colon diſappear, theſe valves almoſt diſappear entirely. Laſtly, the villous coat is thinner, without villi, but porous and wrinkled, furniſhed as well with large peculiar pores of its own leading to round folicles or cells which are ſolitary, as with innumerable ſmall pores leading to ſmaller follicles, both which ſupply a great quantity of mucus.

DCCXLV. The *blood-veſſels* of the large inteſtines are partly from the greater and left meſenterics, and parly from the hypogaſtrics. The middle colic artery ariſes from the large meſenteric trunk, as that deſcends behind the tranſverſe meſocolon, where it ariſes up with one, two, and ſometimes three branches, going to the right ſide with the ileo-colic; and to the left, where, with the lower meſenteric, it meets it in a very large arch, which makes the moſt conſiderable arterial inoſculation in the whole body. Again, under the meſocolon, from the ſame large meſenteric artery, ariſes a conſiderable branch that goes directly to the fold of the ileum with the colon, and upward to the right colon with the middle colic; but to the left it runs together with

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the meſenteric, out of the middle of which it gives a branch that runs along the worm-like appendix of the meſocolon, and terminates itſelf in both the anterior and poſterior fold, by which the ileum is inſerted into the colon. Laſtly, the lower meſenteric, ariſing by its proper trunk from the aorta, betwixt its bifurcation and the renal arteries, goes to the left colon: above, it runs by a large arch, together with the middle colic, and being bent downward in three or four trunks, it ſpreads over the flexure of the colon, and deſcends even into the rectum. Here the rectum receives various branches from the middle hemorrhoidal, ariſing from the laſt trunk of the hypogaſtrics, and conjoined with the former. The ultimate arteries are from the ſame trunk, but diſtributed without the pelvis. We neglect here the ſmaller colics, ariſing from the ſpermatics, intercoſtal, omental, capſulary, and lumbal arteries. The veins, taking the ſame courſe with the arteries, run together into the gaſtrocolic and the internal hemorrhoidal, and hence into the vena portæ; laſtly, they unite with the middle and external hemorrhoidals, and the trunks of the iliacs.

DCCXLVI. The diviſion of the veſſels to the large inteſtines, differs much from that of the ſmall inteſtines. The arches the trunks ſend off, are neither ſo frequent nor ſo often ſubdivided; they run further entire upon the inteſtinal tube, accompanied with fewer glands, and their branches are diſtributed not ſo much like trees; they are divided by leſſer angles, more flexible, and form fewer net-works in the cellular ſubſtance; but they diſtil an exhaling moiſture into the cavity of the inteſtines, as the veins likewiſe abſorb a thin fetid vapour from the feces. The external, and perhaps alſo the internal ones, ſwelling into varices, pour out the hemorrhoidal blood; which is always preternatural, although ſometimes infarctions of the veſſels of the porta are relieved by that evacuation.

DCCXLVII. But there are alſo *lymphatic* veſſels, ariſing from the whole tract of the colon and rectum, which conjoin with thoſe of the loins. We are not without examples of the chyle entering theſe lymphatics from the colon inſtead of lymph; which is an argument that they are of ſome further uſe in this part, by conveying nouriſhment to the blood.

DCCXLVIII. The *nerves* of the large inteſtines are, from the left colic plexus, compoſed by the deſcending branches of each renal plexus, and others ariſing from the intercoſtal trunk of the thorax and loins, with others produced from the large meſenteric plexus. Theſe nerves accompany the lower meſenteric artery, and paſs with them to the colon[164]. The lowermoſt nerves ariſe from the plexus juſt mentioned, and go to the rectum, within the pelvis; others are from the lower intercoſtals, and the nerves of the ſacrum, which terminate likewiſe in the rectum. Theſe nerves are of the ſmaller kind; which renders the inteſtine leſs ſenſible, that it might better ſuſtain the preſſure of the hard and acrid feces.

DCCXLIX. The inteſtinal feces, therefore, retained in the blind beginning of the colon or large inteſtine (DCCLX.), there grow dry by the abſorption of moiſt vapours, ſo as to be capable of receiving a figure from the round contracted parts of the colon; they aſcend from the bottom of the cæcum, elevated by the long ligaments, which end in the worm-like appendix. And here the manner in which the feces are propelled by the contraction of the circular fibres, appears better than in the ſmall ones. The longitudinal fibres of the inteſtine, being attached to the contracted parts as fixed points, draw up and dilate the lower parts of the inteſtine; then the next parts of the inteſtine, to which the feces are brought, being irritated and contracted in like manner, are immediately after drawn together by the round and long fibres; by a ſucceſſive repetition of which the feces finiſh their courſe entirely, through the whole large in-

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[164] An infinite number of nerves, taking their riſe as above mentioned, goes to the great inteſtines; a greater indeed than to the ſmall: They make up a very large plexus upon the meſocolon, with which many filaments are intermixed from the hypogaſtric plexuſes.

teſtine, for the moſt part in 24 hours in a healthy perſon. For wounds in mankind, and the comparative anatomy of brute animals, demonſtrate this periſtaltic motion of the inteſtines to the eye; which is alſo confirmed by the antiperiſtaltic motion, and its conſequences, by which the matter of glyſters is returned up through the mouth. The ſame fibres reſiſt the air contained in the inteſtines; and wind is ſaid to be generated as often as theſe fibres being overcome by its impulſe yield, and the inteſtine is dilated.

DCCL. While the groſs feces aſcend by the folds (DCCXL.) or valves of the ileum, the weight of them depreſſes the lower fold to the left ſide, which draws back the ligament common to each valve, in ſuch a manner as to compreſs and exactly cloſe the upper fold downward, that nothing may return back into the ileum; which might eaſily happen in a fluid ſtate of the feces, if this port was not ſo accurately ſhut up. The feces, when in danger of falling down from the upper parts, depreſs the upper valve, and thus accurately exclude themſelves. This happens very exactly with the feces, but not ſo accurately with water. From thence they continue to move ſlowly forward, more dry, conſiſtent, and figured by the ſame cauſes (DCCXLIX.) through the whole tract and repeated flexures of the colon, which is ſometimes of five or ſeven feet in length, ſo as to retain the feces a ſpace of time ſufficient to give no interruption to the affairs of human life; and this time is proportionably leſs than 24 hours, the greater the velocity with which the ſmall inteſtines propel their contents.

DCCLI. At length the figured excrement falls into the *rectum*, which is inflected firſt a little downwards and then forward, of a broad depreſſed figure, at firſt deſcending contiguous to, and afterwards ſpread under, the bladder, or vagina, but connected more with the former than the latter. Here, for a great while, and often to a great quantity, the feces are collected together,

ther, in a part which is looſe, or openly ſurrounded with ſoft viſcera and muſcles, with a good deal of fat.

DCCLII. The ſtructure of the rectum differs very much from that of the other inteſtines. The external membrane or peritonæum is only ſpread before it; while behind it is ſupported by a broad ſtratum of the cellular ſubſtance, repleniſhed with fat, and many conglobate glandules, connecting this inteſtine all the way to the os ſacrum. The muſcular fibres in this inteſtine are much ſtronger and more numerous, more eſpecially the longitudinal ones, than in the other inteſtines; being compoſed of the three ligaments of the colon, expanded and ſeparated firſt over the anterior face, and then over the whole inteſtine; which they dilate againſt the advancing feces, and draw back the inteſtine after it has excluded them. But the tranſverſe fibres are alſo ſtrong; and the laſt of them are oval, forming a protuberant ring, which is the internal *ſphincter* itſelf, by which the opening of the anus is cloſed.

DCCLIII. Moreover, the villous tunic, extremely full of pores, and of a rough ſurface, full of reticulated polygonous and tender wrinkles, has likewiſe ſome ſinuſes peculiar to itſelf. Namely, that part of the inteſtine which is next to the ſkin or outward opening, forms a white firm circle like a valve, into which deſcend the longitudinal folds, but incurvated and approaching one to another in the circle itſelf. Betwixt thoſe folds, are intercepted ſinuſes, hollow upwards, and of a greater depth towards the lower extremity of the inteſtine. Into the cavity of theſe open the mouths of the large mucous glandules; while the margin of the anus itſelf is defended by ſebaceous glandules, that it might not be excoriated by the harder acrid feces.

DCCLIV. There are alſo proper muſcles which govern the anus. Of theſe the outermoſt is the *ſphincter*, which is broad and fleſhy, conſiſting of two plates of half elliptic fibres, which croſs each other towards the coccyx, and towards the genital parts. And there they are inſerted by fleſhy bundles into a callous cellular

fabric

fabric deſcending from the coccyx. But forward, they are firmly attached, by denſe portions of the ſame kind, to the ſkin of the perinæum; but by three ſtronger portions in the middle, and two in the ſides, they are inſerted into the bulb of the uretha, whoſe lateral parts they ſurround, betwixt the ſphincter and levator[165]. The fibres, therefore, of the ſphincter, placed betwixt the anterior and poſterior face of the rectum, aſcending in a direct courſe, cloſe the opening of the anus, which they ſurround. With the internal ſphincter, the external one is conjoined by fleſhy portions, that they may co-operate together. The conſtriction of them is not perpetual but voluntary; for the anus ſeems to cloſe itſelf naturally, if the ſmallneſs of its opening be compared with the largeneſs of the inteſtine above, and with the correſponding wrinkle (DCCLIII.), aided by the ſtrength of the tranſverſe fibres of the internal ſphincter, and the incumbent bladder.

DCCLV. But there is another office belonging to the *levators*, which are broad complicated muſcles. They deſcend broadly from betwixt the oppoſite protuberances of the oſſa iſchia, placed under the rectum and bladder; and ſerve to ſuſtain the rectum on each ſide, and prevent it from ſubſiding, or from an unſightly everſion. Moreover, the ſame fibres of the levator, declining broadly from each other, in the nature of a ſphincter, to which they join, ſerve to dilate its orbicular fibres, and opens the anus; but, at the ſame time, they both elevate and ſuſtain the inteſtine from prolapſing downward by the preſſure of the hard feces. They ariſe, as is well known, from the ſpine of the iſchium, os ilium, and ſynchondroſis of the oſſa pubis, terminated by the margin of the great foramen of the pubes, and that part of the iſchium which is above the tubercle. Finally, they meet together in one above the coccyx, into which they are inſerted by numerous fibres.

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[165] The inimitable figures of Camper and Santorinus, done with the greateſt clearneſs, have confirmed the truth of the ſtructure of the muſcles of ſphincters, which Albinus's tables repreſent; ſo that almoſt nothing can be added.

DCCLVI. Therefore, whenever the feces are collected to ſome quantity within the rectum, ſo as to be troubleſome by their weight, irritation, or acrimony, they excite an uneaſineſs through the adjacent viſcera; and are then urged downward, by a voluntary preſſure through the ſtraits of the collapſed inteſtine (DCCLIV.), by the force of the incumbent diaphragm, exciting an effort; which urging downward with great force, the viſcera of the abdomen, which is always full, are determined downward, through the inner rim of the pelvis, ſo as to urge upon the contents of the leſs reſiſting bladder and rectum. When the reſiſtance of the anus is thus overcome, the compreſſing forces of the diaphragm abate, and the feces continue to diſcharge from the body, urged only by the periſtaltic motion itſelf of the inteſtine. After the feces are expelled, the inteſtine is drawn back or up into the body, by its longitudinal fibres; after which, the opening of the anus itſelf is cloſely contracted by the two proper ſphincters, as at firſt.

DCCLVII. Theſe feces in men, and carnivorous animals, are very fetid, almoſt putrid, ſubalkaline, ſoft, and contain much oil intimately mixed with ſalts, which are left both by the aliments, as well as by the bile and other humours of the human body. An acrid and fetid water returns from the feces into the blood; hence, coſtiveneſs in fevers is hurtful, putrefaction being increaſed by the affuſion of the abovementioned matter into the body.

CHAP. XXVII.

Of the Chyliferous VESSELS.

DCCLVIII. THE chyle is a white juice (DCCXXXVI) extracted from the aliments, which is afterwards mixed with the blood. That its principal compoſition is of water and oil, ſeems evident, from the ſweetneſs of its taſte, from the whiteneſs of its colour, from its aceſcent and coagulable nature, and from its lightneſs by which it ſwims on the blood; in all which properties it very much reſembles an emulſion. It is compoſed of a vegetable farina, with animal lymph and oil. It every where retains the properties of the volatile and oily aliments. It changes into milk with very little alteration. But afterwards it becomes more manifeſtly glutinous; ſince the pellucid ſerum it contains, either by exhaling the watery part, or by applying an intenſe heat, coagulates into a kind of jelly.

DCCLIX. That the chyle is abſorbed into the lacteal veſſels, by the adhering villous coat, has been a long time known, by experiments of injecting tinctured liquors, which readily deſcribe the ſame courſe; from the white liquor of the lacteals, let out from blood-veſſels; and from the venous nature of them. But late experiments have taught us this in a much better manner. The chyle is abſorbed by a ſmall opening in the extremity of each of the villi, by the ſame force which is common to all capillary tubes, by which it is taken up into the cavity of the abſorbing duct at the time when the inteſtine is relaxed; but the veſicle, by which the abſorbing duct begins in the inteſtine, being preſſed by the ſucceeding conſtriction of the muſcular fibres in the periſtaltic motion, urges the contents further on into the duct, which begins to appear within the ſecond cellular ſtratum. But there is a two-fold ſtratum of theſe abſorbing veſſels, one anterior, the other poſterior, as we obſerved before of the blood-veſſels (DCCXXIX.). From thence, uniting into a larger canal in the firſt cellular ſtratum, the abſorbed liquor enters into the lacteal veſſel, which, in general, follows the courſe of the arteries[166], and likewiſe accompanies their arches, but conjoined with others ſimilar to it into a very obliquely angled net-work. This kind of veſſels hitherto has been obſerved only in quadrupeds[167]. In the large inteſtine they ariſe without the abovementioned veſicle. Very many ariſe from the firſt part of the ſmall inteſtines under the meſocolon; ſome from the duodenum, and ſome from the large inteſtines themſelves.

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[166] To the very elegant drawings of the lacteals in their courſe through the meſentery, given by Aſellius, Cowper, Bils, Duverney, Cheſelden, Stuart, &c. we ſhould add the new ones of Hewſon and Santorinus.

DCCLX. The lacteal veſſels are furniſhed with valves in the very firſt cellular texture of the inteſtine, like thoſe of the lymphatics, joined together by pairs, of a ſemilunar figure (LVII.), which admit the chyle paſſing from the inteſtines, but prevent its return, and ſuſtain its weight. Through this whole courſe, the chyle is urged on by the periſtaltic motion of the inteſtines, as well as by the contractile force of the veſſels themſelves, which, even after death, is ſtrong enough to propel the chyle; to which add, the conſiderable preſſure of the abdominal muſcles, and other parts, determined by the valves.

DCCLXI. But betwixt the plates of the meſentery, at the diviſions of the veſſels, are found an infinite number of ſmall conglobate glandules, but ſomewhat ſofter and more ſpongy, made of a cellular texture, full of juices, covered with an external membrane, leſs hard than in other parts, and painted with numberleſs ſmall blood-veſſels. Some lacteal veſſels are ſeen to paſs theſe glands; moſt part enter them; and, being divided and ſubdivided through their cellular fabric, compoſe the greateſt part of the gland. And, again, other lacteal veſſels are produced out of every gland; and, being mutually joined among themſelves, go off in little trunks, of which the ultimate and largeſt ones go out from the gland. In the ſame manner the chyle enters other glandules twice, thrice, or four times; nor does any lacteal veſſel arrive at the thoracic duct without meeting ſome of theſe glandules, although it may paſs by ſome without entering them. But that this is the true courſe of the chyle, by which it paſſes from the inteſtines to the meſenteric glands, appears from a ligature, by the veſſel growing turgid betwixt the ſaid ligature and the inteſtine; and from ſcirrhoſities in the glands, by which they are rendered more conſpicuous; and from the nature of the valves themſelves hindering any return back to the inteſtines.

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[167] There is no longer a diſpute, whether the mammalia quadrupedes alone have lacteal veſſels, ſince the induſtrious Mr Hewſon has ſhown them in birds and amphibia; and it is no difficult matter to ſhow them in many others, as dolphins and ſea-calves; and Dr Hunter uſed to render theſe veſſels viſible with very little trouble.

DCCLXII. What alteration the chyle undergoes within the cellular fabric of theſe glands is not yet ſufficiently known; but it appears, in general, that ſome thin liquor diſtils from the arteries in this part, ſerving to dilute the chyle, into which it is poured. For it is obſerved, that after the chyle has ſurmounted all the glands, it appears more watery; and thin liquors, injected through the arteries, paſs out into the cellular fabric of the glands, and mix with the chyle. Laſtly, that kind of cream appears manifeſtly in the glandules of infants.

DCCLXIII. From the laſt glandules, which are collected together in the centre of the meſentery, the lacteal veſſels go out very large, and few, to the number of four, five, or more, which aſcend together with the meſenteric artery, and intermix with the lymphatic plexus, that aſcends from all the lower parts of the body, creeps over the renal vein, and then goes along with that which takes its courſe behind the aorta from the lumbar glandules, and with the hepatics. Here the lymphatics take a variable courſe, but moſt frequently terminate in a veſicle of conſiderable breadth at the ſide of the aorta, betwixt that and the right appendix of the diaphragm: there it uſually appears ſomewhat turgid, two or more inches long; and often aſcends above the diaphragm into the thorax, conical both above and below: it is called the *receptacle of the chyle.* In this the gelatinous lymph of the lower limbs, and of the abdominal viſcera, mixes with the chyle, and dilutes its white colour; thus ſometimes it appears filled with a pellucid or reddiſh humour, but frequently alſo with a white milk. But there are ſome inſtances where there are only two or three ſmall and narrow ducts, inſtead of this receptacle or ciſtern of the chyle. This, however, is moſt frequent, and ſuffers a conſiderable alternate preſſure from the diaphragm and aorta, by which the chyle is moved faſter through it, in proportion as the light of the ciſtern is greater than that of the thoracic duct, into which it empties itſelf. Yet ſometimes, though rarely, this veſicle is ſo ſhort, that it may be compared with an egg; but for the moſt part it is broadeſt in the middle, and decreaſes conically towards each end.

DCCLXIV. That the chyle comes from the inteſtines into this duct, is ſhown from injections, by which quickſilver has ſometimes been driven from the firſt lacteal veſſels to the thoracic duct; from ligatures made on the duct itſelf, or the red veins which receive it, and by which the firſt and ſecond lacteal veſſels ſwell; and from the manifeſt flux of the chyle into the thoracic duct, when the ligatures are removed.

DCCLXV. The *thoracic duct*, as it is called from its courſe, is generally ſingle; or, if it be double for ſome part of its courſe, it ſoon after unites into one again, which goes behind the pleura, betwixt the vena azygos and the aorta; and, aſcending in an inflected courſe, it receives in its way the lymphatic veſſels of the ſtomach, œſophagus, and lungs, and paſſes through the conglobate glands, of which there are many incumbent on and about it; and theſe lymphatics, as they advance towards the duct, are collected into large bunches. It is, in general, cylindrical; and often forms inſulations, by ſplitting or dividing into two or more; after which it unites into one again, more eſpecially in its upper part. It has few valves, and thoſe not very conſpicuous. About the fifth vertebra of the back, it generally croſſes behind the œſophagus, and then aſcends along the right ſide of the thorax, behind the ſubclavian blood-veſſels till it has arrived near the ſixth vertebra of the neck.

DCCLXVI. There, bending down, it often divides into two, and each deſcending branch dilates into a ſort of veſicle that enters, either with diſtinct or united openings, into the juncture of the ſubclavian and jugular vein internally, by an oblique courſe from the upper, poſterior, and lateral part downward towards the left, and forward, going either with one or with two branches under the ſubclavian, on the outer ſide of that juncture. It has a true almoſt circular fluctuating valve, which by its deſcent keeps out the blood ready to enter. It is rarely otherwiſe diſpoſed; and more rarely ſplit into two, for diſtinct inſertions into the ſubclavian; and yet more rarely apt to ſend off a branch into the vena azygos. Near its inſertion it receives the opening of a large lympatic veſſel, tranſverſely from the arm; and another deſcending from the head, in one or more trunks.

DCCLXVII. It appears that the chyle flows through the thoracic duct into the blood; becauſe, on tying the red veins, both the thoracic duct and lacteal veſſels which are inſerted into it ſwell up.

DCCLXVIII. I have attributed the firſt cauſe of motion in the chyle, and of its abſorption, eſpecially to the attraction of the capillary veſſels, which obſerves alternate pulſes with the periſtaltic contraction of the inteſtine. The attractile force fills the villoſity; the periſtaltic force empties the villoſity, and moves the chyle farther forward. The reſt of its motions ſeem to depend on the ſtrength of the membrane of the lacteal veſſel itſelf, which, even after the death of the animal, expels the chyle, ſo that the veſſels become pellucid, which before were milky. The alternate compreſſing force of the diaphragm alſo is of ſome efficacy in this caſe, and the motion of the chyle through the thorax is ſomewhat accelerated by the conduit itſelf; which being preſſed, moves the chyle ſo much the more quickly forward, as itſelf is larger than the thoracic duct.

DCCLXIX. The chyle, mixed with the blood, does not immediately change its nature; as we learn from the milk, which is afterwards made of it. But after five or more hours have paſſed from the meal, almoſt to the twelfth hour, during all which ſpace a woman will afford milk; after it has circulated near 80,000 times through the body, fomented with heat, and mixed with a variety of animal juices, it is at length ſo changed, that a part of it is depoſited into the cellular ſubſtance, under the denomination of fat; a part of it is again configured into the red-blood globules (CXLVII.); another part, that is of a mucous or gelatinous nature, changes into ſerum; and the watery parts go off, in ſome meaſure, by urine, in ſome meaſure exhaled by perſpiration; while a ſmall part is retained in the habit to dilute the blood. Nor is it any thing uncommon for a pellucid lymphatic liquor to fill the lacteals, in a dying animal, inſtead of chyle; or for ſome of them to appear milky in one part of the meſentery, and limpid or pellucid in another; ſince, as to their fabric and uſe, they alſo agree to anſwer the end of lymphatics. There are not, therefore, two kinds of veſſels from the inteſtines; one to carry the chyle only, and another peculiarly for the conveyance of lymph.

DCCLXX. After the digeſtion has been completed ſome time, the lacteal veſſels abſorb pellucid watery juices from the inteſtines, whence they appear themſelves diaphanous; but the thoracic duct is more eſpecially a lymphatic of the largeſt order, conveying all the lymph of the abdomen, lower extremities, and moſt parts of the body, to the blood (LIII.)

CHAP. XXVIII.

Of the KIDNEYS, BLADDER, *and* URINE.

DCCXXI. THE chyle, which is taken into the blood, contains a good deal of water; the proportion of which would be too great in the veſſels, ſo as to paſs into the cellular ſubſtance, if it was not expelled again from the body. Therefore a part of this is exhaled through the ſkin (CCCCXXXVI.); and another part, as large, or often larger than the former, is ſtrained through the kidneys, and is expelled out of the body.

DCCLXXII. Theſe *kidneys* are two viſcera [168], placed on each ſide the ſpine of the back, behind the peritonæum, incumbent upon the diaphragm, and upon the pſoas and quadratus muſcles of the loins; but in ſuch a manner, that the right kidney is commonly placed lower and more backward than the left. Before the right kidney is placed the liver upon its upper part, (DCXC), and then the colon covers the reſt of its anterior face; and the left kidney is alſo covered by the ſpleen, ſtomach, part of the pancreas, and the colon. They are tied by reduplications of the peritonæum to the colon, duodenum, liver, and ſpleen. Their figure is externally convex, with a ſemielliptic deficiency in their inner ſide; laterally they are flat or depreſſed, inwardly hollow, unequally divided into one upper or longer and thicker plane, and lower ſlenderer extremity. They are firmly inveſted by a ſtrong external membrane, which is denſe, adheres very cloſely, and does not come from the peritonæum [169]. Betwixt that membrane and the peritonæum of the loins, there is always interpoſed a conſiderable quantity of fat, by which the whole ſurface of the kidney is ſurrounded on all ſides, and a neſt is completed, which the kidney does not totally fill, though anſwering to its ſhape. From the kidney the peritonæum aſcends to the liver, ſpleen, colon, and diaphragm, and prepares as it were ligaments for the kidney.

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[168] I have ſeen two caſes of one kidney only; in one, the kidneys being joined, directed the arch upwards; in another downwards: but in fact I ſaw another ſubject, in which there was only one in one ſide, and in the other no veſtige of veſſels or the viſcus appeared.

[169] A very pretty net-work of blood-veſſels is diſtributed over this coat of the kidneys, coming partly from the renal veſſels, and partly from others.

DCCLXXIII. The *blood-veſſels* of the kidneys are very large, as well the arteries, which together exceed the meſenteric, as the veins. And firſt, the renal *arteries* paſs out from the aorta under that of the meſentery, not always in the ſame manner, yet ſo that the left is commonly ſhorter than the right, and each of them frequently in two, three, or four diſtinct trunks. From thoſe trunks ariſe the renal arteries of the lower ſort, with the adipoſe ones belonging to the fat cortex or capſule of the kidney (DCCLXXII.); and not unfrequently they give origin to the ſpermatics. The fat, rather than the kidney, receives the ſmaller branches from the ſpermatics and arteries of the loins. The arteries are thick, ſo that there is a great quantity of membranes in proportion to their light; they are alſo made of very ſtrong ones, and exceed the ſtrength of the aorta by a third part.

DCCLXXIV. The renal *veins* are very large, more eſpecially the left, and more inconſtant in their courſe than the arteries: for the right is often without a branch, ſhort and concealed; while the left always generates the ſpermatic and capſular vein of the ſame ſide, and almoſt conſtantly receives the laſt branch of the vena ſine pari; and being of a conſiderable breadth, it extends a long way tranſverſely, and produced to the left, before the aorta, with the duodenum incumbent upon it. Both the arteries and veins of the kidneys ariſe from the great trunks laterally, a little deſcending in an obtuſe angle; and divide themſelves into many branches, a little before they enter the kidney. That the paſſage of the blood through the renal arteries into the veins is very expeditious, readily appears from the eaſy courſe that is afforded to water, wax, or even air, injected. The uppermoſt veins of the fat of the kidneys come from the capſular veſſels, the middle from the renal ones, and the lowermoſt from the ſpermatics.

DCCLXXV. There are *lymphatic* veins, conſiderably large, found about the renal blood-veſſels, which give origin to the ciſtern of the chyle (DCCLXIII.), which are ſaid to receive the diſperſed branches that are ſpread under the cellular coat of the kidney, and which are rendered manifeſt by putrefaction, or liquor injected into the renal arteries, or even into the ureter.

DCCLXXVI. The *nerves* of the kidneys are ſmall, but numerous; ariſing from a conſiderable plexus, mixed on each ſide with ganglions which are generated by the branches of the great ſemilunar ganglion, conjoined with others from the intercoſtal trunk, creeping along from the thorax itſelf. They enter the kidney, together with the artery, and ſend off the middle meſenteric (DCCXLVIII.), and likewiſe the ſpermatic nerves. As theſe nerves are ſmall, they afford but a moderate degree of ſenſibility to the kidney.

DCCLXXVII. Upon the top of each kidney is ſeated the *renal capſule;* which in the fœtus is large, even larger than the kidney itſelf, but not afterwards increaſing in the adult: it is glandulous, of the conglomerate kind, divided into lobes, of an oval ſhape in the fœtus, and triangular in the adult; and connected on the right ſide to the liver, ſpleen, pancreas, on both ſides to the diaphragm and kidney; to all which it adheres by as many connecting twigs. From a careful obſervation, it ſeems to be inwardly hollow, ſeparable like a ventricle, of a ſmooth ſurface, and terminating inwardly, as if cut with a razor, full of a liquor of a yellowiſh red colour, and of a fluid conſiſtence, almoſt like blood. The arteries of theſe capſules are many, chiefly of three kinds; the uppermoſt from the phrenics, the middle ones from the aorta, and the lower ones from the renals; but the veins are only a large one on each ſide, that of the right to the cava, and the left to the renal vein of the ſame ſide. The ſaid vein creeps almoſt naked, in branches, through the tender ventricle, in a ſulcus, dividing the capſule, and ſends branches through its internal ſuperficies. The uſes of this gland are as yet unknown; although we are led to believe, from the ſituation, that it is ſubſervient to the kidney, and of greater uſe to the fœtus; ſince it is conſtantly found near the kidneys, and in ſo many different animals. It has no viſible excretory duct, nor does it diſcharge any juice, by viſible pores, into the vein.

DCCLXXVIII. The internal fabric of the kidney is ſimple enough, and ſufficiently known. The blood-veſſels having entered the interval betwixt the upper and lower ſtratum of the kidney, ſpread into its ſubſtance, ſurrounded with a cellular ſheath, and divide into branches which go out between the branches of that which is called the *artery of the pelvis*, by columns interpoſed betwixt the papillæ. From thence, both in the papillæ and among them, making arches, they ſurround the origin of the papillæ, nearer to the circumference; but ſometimes joined by ſmall branches: from whence proceed innumerable little twigs, of which ſome return into the papillæ by the intervals between them and the columns; others tend towards the external ſurface of the kidney, and ſometimes, paſſing through the proper coat of the kidney itſelf, enter into its adipoſe covering, where being changed into minute ſerpentine curls, reflected again towards the trunk of the artery from whence they roſe, they form a boundary to the kidney, and are then gradually ſtretched out and mix themſelves among the uriniferous tubes. But from the cortex, as it were by ſome little flames, are produced bundles of the uriniferous tubes collected in great numbers into threads, of which every one contains very many little tubes. That they are continuous with the arteries, or at leaſt that they receive their branches into them, we know, from experiments which ſhow that water, or even air, paſſes eaſily from the arteries of the kidneys into the ureter; and laſtly from diſeaſes, in which the blood takes the ſame courſe. Between theſe papillæ, and about their origin, are ſituated ſome roundiſh knots, which the lateſt anatomiſts take to be the arterial glands, producing the proper and more narrow urinary ducts. Between theſe ſmall ducts run many arteries parallel to one another. It is probable, that the cortex conſiſts of curved veſſels, which eminent anatomiſts have ſuppoſed to be ſmaller than the red ones.

DCCLXXIX. Thoſe *uriniferous ducts*, gradually converging towards the middle of the kidney, are joined together like rays; and are inſerted in great numbers into one blind duct, ſuch as perfect the reſt of the papillæ; and each of which is terminated in its convex extremity by conſpicuous pores. The number of theſe papillæ is not altogether certain, but there are thirteen or more of them; ſome of which are obſerved to be ſimple, ſome triple, and ſome quadruple. Theſe were in the fœtus ſo diſtinct, that the kidney then appeared to conſiſt of as many diſtinct or ſmaller kidneys, as there are of theſe papillæ, connected together by a looſe cellular membrane; and furniſhed every one with its proper cortex of ſerpentine veſſels, and its compages of ſtraight uriniferous ducts, the baſis of all which is in the circumference of the kidney, and their vertices converge towards the centre. The oppoſite cortices of two of theſe little kidneys make a column, becauſe it ſeparates two papillæ. In adults, the cellular ſubſtance being condenſed, unites the renal portions and their papillæ into one even kidney: however, it again almoſt recovers the condition which it had in the fœtus, if the intervening cellular plates are relaxed by often injecting of water. The kidney is alſo remarkably larger in the fœtus than in the adult.

DCCLXXX. Round the protuberant ſurface of the ſaid papillæ, is extended a looſe membranous covering, in ſuch a manner, diſtinct from the papillæ itſelf, as to form a larger ſpace, like a cylindrical tube or funnel, for receiving the papillæ into its cavity, and ſometimes there are two in the neighbourhood of each other. Two or three of theſe tubes meet together in one; and with others of the ſame kind, they at laſt form by that union three hollow trunks, the upper, middle, and lower, which again unite and open, but without the kidney, into one conical canal, called the *pelvis* [170].

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[170] In almoſt no viſcus are there more frequent luſus naturæ, both

DCCLXXXI. The blood of the renal artery being leſs fluid, as is generally believed, than that of the brain, and probably ſtored with more water, brought by the ſerpentine circles of the arteries, depoſites great part of its water into thoſe rectilineal tubes of the papillæ; a great portion of which water contains oils and ſalts, intermixed with earthy particles, or ſuch other matters as are thin enough to paſs through with it. But the ſmall diameter of each uriniferous duct itſelf at its origin, and its firm reſiſtance, ſeem to exclude the milk or chyle and the coagulable lymph. Hence, therefore, it is, that the blood paſſes ſo eaſily through the open uriniferous tubes, whenever it is urged with an increaſed celerity; or, by a morbid relaxation, they tranſmit not only the oily parts of the blood, but even the milk and ſalts of the meat and drink. But when the ſtrength of the kidney is reſtored by aſtringent medicines, the urine returns to its natural ſtate. The nerves likewiſe have a power of contracting or relaxing theſe paſſages; and thus we ſee that urine, which in health is of a yellow colour, becomes watery from ſudden grief of mind. A vaſt quantity is prepared; equal to that of perſpiration, and ſometimes even more.

DCCLXXXII. The urine, by fire or putrefaction, ſometimes by diſeaſe, and in ſome animals more eaſily, changes into a volatile alkaline nature, intimately mixed with a fetid oil, partly empyreumatic, yellow, and volatile, and in part very tenacious, to be ſeparated only by the laſt degrees of fire, under the denomination of phoſphorus; a ſubſtance ſhining of itſelf, and taking fire in the air: and laſtly, it abounds more with earth than any other juice of the human body, both of a cretaceous and ſparry nature; the latter coming chiefly from the drink, the former alſo from the ſolid parts of the body themſelves diſſolved and mixed with the blood. But there is alſo a conſiderable proportion of ſea-ſalt reſiding in

as to their bulk, number of veſſels, pelvis, and ureter, than in the kidneys. I have collected a great catalogue, and Sandifort has remarked many varieties.

freſh urine; from which it is even ſeparable, after a long putrefaction, in the making of phoſphorus; in which proceſs a very great part of the urine is changed into volatile alkali. Nor is the urine wholly deſtitute of a vitriolic acid, or at leaſt one much a-kin to it; both in that taken from men, as well as cattle. There is, again, a ſort of fuſible ſalt ſeparable in the urine, which is cooling, and a-kin to nitre. In fevers, the oily and ſaline parts of the urine are greatly augmented both in bulk and acrimony.

DCCLXXXIII. The *ureter* being a continuation of the pelvis, carries on the urine received from the kidney, by preſſure from the incumbent viſcera, the contraction of the abdominal muſcles with thoſe of the loins, and the force of the circulation urging the blood behind the ſecerned fluid, and laſtly the weight of the urine itſelf. Firſt, the ureter is covered by the peritonæum and cellular membrane; but its muſcular coat is weak, obſcure, if any: it has then a ſecond cellular coat; a firm, white, nervous one; a third cellular one, lined with the innermoſt, which is of a ſmooth membranous fabric, porous and glandular internally, and in general moderately irritable. It is of different diameters in different places, and every where ſwells into veſicles. It deſcends over the pſoas muſcle, croſſes over the great iliac blood-veſſels into the pelvis; goes behind the urinary bladder; and in the conjunction of the deſcending and tranſverſe portions of the bladder, enters obliquely betwixt the muſcular fibres and nervous coat; and ſo again, betwixt the nervous and villous coat, in ſuch a manner that the mouths of the two ureters are in the neighbourhood of each other, and open by an orifice obliquely cut off; but they have no valves, neither at their opening in the bladder, nor in any part of their courſe. From their oblique inſertion into the bladder, a protuberant line is formed, by the greater thickneſs of the nervous coat, which deſcends to the caput gallinaginis.

DCCLXXXIV. That the urine is ſeparated in the kidneys, is ſhown by the very nature of the thing, as it can be drawn out by preſſing on its ſmall canals. That it deſcends by the ureter is ſhown by the ſurpriſing ſwelling of the kidney, and that part of the ureter which is above the ligature, as well as the emptineſs of that part which is below it. In the bladder alſo, as well as in the kidneys and ureters, there is an immenſe ſwelling as often as the bladder cannot receive the urine, or cannot emit it; an obſtacle being generated in either place.

DCCLXXXV. Nor does there ſeem to be any other way for the urine to paſs. For although it is certain, that the ſtomach, like all other membranes, exhales a moiſture through its coats; though it is not improbable, from experiments, that the bladder alſo abſorbs; and although the paſſage of mineral Spaw waters, by urine, be extremely quick; yet it does not thence follow, that there muſt be ways, different from that of the ureters, to convey the water from the food to the bladder. For the bladder is, on all ſides, ſeparated from the cavity of the abdomen by the peritonæum; nor is it very likely, that the vapours, which either go out from the bladder, or which are derived towards it from other parts, can here find open pores through the peritonæum; nor do membranes imbibe much that are already wetted, ſo as to fill their pores with humours. But the urine alſo which is contained in the bladder, diſtends it even to death; nor does it find any paſſage through which it can eſcape into the pelvis; and on the other hand, when the ureters are obſtructed with ſtones, ſo that the bladder receives nothing from them, it is either quite empty, or contains a very acrimonious and thick urine, manifeſtly indicating that the water can find no other way from the pelvis into the bladder. And a careful attention to the manner in which mineral waters are diſcharged by urine, ſufficiently demonſtrates, that there is no ſuch rapidity therein as is commonly imagined; but the ſtimulus of the cold water drank, does, like the external cold applied to the ſkin, cauſe a concuſſion of the bladder and urinary parts, by which they are ſolicited to repeated diſcharges of the old urine which was before in the body, and not immediately of that which was laſt drank. Again, the largeneſs of the renal veſſels demonſtrates, that not much leſs than an eighth part of the blood ſent to the body is received at a time, and conſequently there are above 1000 ounces of blood conveyed through the kidneys in an hour; whence it will appear but a moderate allowance, for 20, or even 50, ounces of water to diſtil from that quantity of blood driven through the kidneys in the ſame time. Finally, it is certain, that both man and brute animals periſh if the ureters are cloſed up by a ligature; we then obſerve alſo, that no urine can be found in the bladder.

DCCLXXXVI. The *urinary bladder* is ſeated in the cavity or bowl of the pelvis, which is an appendix to the abdomen, ſurrounded on all ſides by bones; but laterally, and at the bottom, only incloſed by muſcles; and is always larger in women than in men. It is ſituated, ſo as to cohere with the os pubis by a large portion of cellular ſubſtance, by which it is connected to the peritonæum, from thence backward, and for a ſmall part of its ſurface before; but behind, it is extended to a greater length over the bladder, deſcending almoſt as far as the inſertions of the ureters; from whence it returns back again, either over the rectum or uterus in women. Behind the bladder lies the rectum, the ſeminal veſicles, and proſtate gland, with the levatores ani. In the fœtus, the bladder is very long, and ſomewhat conical, extending itſelf much above the oſſa pubis; but in the adult, it hardly ariſes above thoſe bones, even when inflated, becauſe, in them, the pelvis is much larger and deeper in proportion.

DCCLXXXVII. The figure of the bladder is, in general, oval, flatter before, more convex behind, terminated at bottom by a very obtuſe or flat head, that lies incumbent upon the rectum. Such is the figure of it in an adult man: but, in the fœtus, it is almoſt cylindrical; and, in women who have had many children, ſo much

flattened

flattened laterally by preſſure, that it reſembles a ſort of triangular cone. This change of the figure of the bladder ſeems to ariſe from the weight of the urine, gradually diſtending more the lower parts of the bladder, which are moſt preſſed; by which means the ſides are drawn together from above, ſo as to render it ſhorter and broader. It is of different magnitudes; ſo that, in diſeaſes, by frequent irritation and contraction, it ſometimes becomes very ſmall.

DCCLXXXVIII. The fabric of the bladder is much like that of all large membranous receptacles. The firſt membrane is cellular; in its forepart lax, and repleniſhed with fat; but backward it is thinner, where it unites with the rectum. In this there is a net-work of veſſels, chiefly of veins. Next to this follows a muſcular coat, very difficult to deſcribe, conſiſting of pale contractile fibres, diſpoſed in various reticulated bundles, not continued one to another, but interrupted with net-like ſpaces, in which the nervous coat lies uncovered. The principal ſtratum of theſe is longitudinal; which, ariſing before from the proſtate, is frequently, though not always, ſo connected to the ſynchondroſis of the oſſa pubis, or the membranes covering it, as ſeemingly to ariſe from thence; thence, aſcending and growing broad, they ſpread towards the conical extremity of the upper ſide of the bladder: here paſſing on, they deſcend over the poſterior ſurface, and grow there conſiderably broader, till at length they are finally terminated in the proſtate; but laterally they go off like the palms of one's hands, and are mixed from the anterior and poſterior planes. Theſe fibres muſt neceſſarily depreſs the bladder, and conſequently propel the urine towards its bottom[171].

DCCLXXXIX. The remaining fibres are very difficultly reduced to any order. They fill the intervals of the former; by ariſing from the proſtate backward and aſcending inflected, they form a ſtratum, partly oblique, and partly tranſverſe, the interior ones more than the others,

[171] The accurate figures of Santorinus, publiſhed ſince Parſonius, are undoubtedly elegant and accurate. But nature obſerves no regular rule in theſe muſcular fibres.

others, both in the forward and back part of the bladder.

DCCXC. The contractile force of the bladder is gentle, but perpetual; ſo that it contracts from its greateſt dilatation to its very leaſt ſize, without any alternate relaxation, and remains long in its ſtate of greateſt contraction. The urine is the leaſt uneaſy ſtimulus; water injected is more ſo, and a ſtone the moſt of any kind of irritating ſubſtance. When diſtended beyond meaſure, it loſes its powers; ſo that it either cannot expel, or cannot retain, the urine.

DCCXCI. Within the muſcular coat is ſpread the ſecond cellular ſtratum, of a tender elegant fabric, that may be inflated, and ſofter than that obſerved in the inteſtines. Next follows the nervous coat[172], as a continuation of the ſkin, and reſembling the nervous coat of the ſtomach: the inner one is more obſcure; difficultly ſeparable from the nervous one; continuous with the epidermis; and, like it, eaſily ſeparable, having a great deal of mucus, and folded into various wrinkles, without any certain order. In the ſurface of this laſt, the pores of the mucous cryptæ ſometimes appear conſpicuous, but not always without difficulty, pouring out a viſcid ſoft glue. The mucus itſelf is very manifeſt, and is prepared in the greater quantity in proportion to the irritation of the bladder. For this mucus there is the higheſt neceſſity, to diminiſh the ſenſation of the acrimony of the urine.

DCCXCII. The *veſſels* and *nerves* of the bladder are in common with thoſe which go to the genital parts, where we ſhall deſcribe them. Thoſe which come from the epigaſtrics are but ſmall. They form principally a net-work in the firſt or outer cellular ſtratum, and then another in the ſecond ſtratum of the ſame ſubſtance. The arteries exhale through the villous coat, as we learn by experiment from anatomical injections;

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[172] We ſhould renounce the name of Nervous coat, both in the bladder and inteſtines, on account of the falſe idea of the origin and nature which it involves; for it neither ſo acutely feels, nor ariſes from nerves: it is only a compact cellular membrane.

and the veins likewiſe abſorb again, to which is owing the greater conſiſtence and higher colour of the urine by a long retention of it. The lymphatic veſſels in the outer cellular ſtratum, are eaſily demonſtrated; but their origin is from another part, probably from the adjacent rectum.

DCCXCIII. The ſame urinary bladder is of the nature of other membranous ſacs, ſo that it both tranſmits water through the inorganic pores of its membranes, and through the ſame abſorbs the water in which it is immerſed.

DCCXCIV. Into this bladder the urine conſtantly flows, in a continued thread, as we are aſſured, from experience, in morbid and uncommon caſes, in which the extremities of the ureters have appeared to the eye. By ſtaying ſome time in the bladder, and from the abſorption of the more watery part, the urine acquires an higher colour, becomes ſharper and reddiſh-coloured. Nor are we fully acquainted with the cauſe which retains the urine in the bladder. The ſphincter is obſcure; the depreſſion of the bladder ſeems to aſſiſt, as it deſcends convex below its mouth upon the inteſtinum rectum, ſo that at laſt the urine arrives at the entrance of the urethra when any quantity of it is collected. Certain it is, that the urine does not flow ſpontaneouſly even from a dead carcaſe.

DCCXCV. At length, by its bulk and acrimony, irritating the ſenſible fabric of the bladder, it is thence expelled, firſt by the motion of the diaphragm and abdominal muſcles, by which the inteſtines are urged againſt the bladder in a perſon who is erect, whereby the urine makes itſelf a way through a narrow and impeded paſſage; and again, by the periſtaltic motion of the bladder itſelf, ariſing from the contraction of its muſcular fabric (DCCLXXXVIII, et ſeq.)

DCCXCVI. By the urine, beſides the particles of food and water, much matter ſeems to paſs off that is noxious to the human body; eſpecially calcareous earth reſorbed from the bones and ſolid parts, and which would not fail to produce bony cruſts and calculi whereever it was ſtopped; the ſparry or gypſeous earth of fountains; an acrid oil mixed with ſalt, ſo as to aſſume a volatile nature. The urine, by its retention, diſpoſes to the generation of the ſtone and gout: when ſuppreſſed, it produces ſharp fevers; and at laſt flows back to the brain, and overflows and deſtroys it.

DCCXCVII. From the anterior vertex of the obtuſe or greater end of the bladder, not from its bottom, goes out a ſlender canal with a ſmall orifice, as a continuation of the bladder itſelf, under the denomination of the *urethra;* and in this, there is a manifeſt continuation of the cuticle of the internal coat of the bladder, with its ſurrounding cellular ſubſtance, and more eſpecially a ſolid nervous coat, of which it is principally compoſed. It is variable in its diameter and direction; in women, it is ſtraight, tranſverſe, and ſhort. I do not find a valve in its mouth.

DCCXCVIII. This canal of the urethra is firſt ſurrounded, on all ſides, by the proſtate gland; from whence it goes out naked, for a ſmall ſpace, that is immediately continuous below with the incipient bulb of the urethra, which likewiſe ſurrounds it on all ſides above; but the cavernous bodies of the penis chiefly cover it above and laterally, ſo as to form a common groove for its reception, and add ſtrength or firmneſs to this otherwiſe lax tube. It begins wide from the bladder, and contracts itſelf conically in the proſtate; from which, being at liberty, it becomes cylindrical, and enlarges at the firſt acceſſion of the bulb; in the penis it is almoſt cylindrical, and again dilates itſelf a little before its termination.

DCCXCIX. This canal is governed by various muſcles, either proper to itſelf, or belonging to the parts adjacent. And firſt, in women, there are manifeſtly fibres placed round the egreſs of the incipient urethra, which are moſtly tranſverſe, but ſome variouſly decuſſating each other; whoſe office, and ſupport in the vagina, manifeſtly appear; namely, to depreſs the urethra, like the ſphincter, about the opening of which they are diſpoſed, and by this means to cloſe its opening againſt the reſiſting contracted vagina and ſphincter of the anus[173]. In man there are tranſverſe fibres of the ſame kind; but, forming an arch that opens upward, they run into the conjunction of the bladder with the proſtate, covering the longitudinal bundle of fibres and proſtate itſelf, which covering of fibres thus become fit for contracting the orifice of the bladder.

DCCC. The firſt tranſverſe muſcle proceeding from that bunch of the iſchium which ſends forth the erector muſcle of the penis, goes tranſverſely towards the other os iſchium, partly paſſes into it, is partly inſerted into the middle bulb of the urethra, and partly degenerates into the accelerator. It preſſes upon, ſhakes, and draws backward, the bulb of the urethra. The other, produced from a branch of the os iſchium, is inſerted into the iſthmus of the urethra before the bulb, and dilates it.

DCCCI. But likewiſe the levator of the anus ſeems to raiſe the urethra againſt the os pubis, ſo as to cloſe the opening of the bladder into it; and, in ourſelves living, we may perceive the accelerator conſtringed, together with the ſphincter, at the root of the penis, ſo as perfectly to cloſe the opening of the urethra, and preſs back the urine even while it is flowing; whence there is no room to doubt, but this muſcle gives a moderate tightneſs for retaining the urine.

DCCCII. An effort being now made (DCCXCV.) by the preſſure of the diaphragm, the urine runs forth with a greater celerity, in proportion as it comes through a canal ſmaller than the diameter of its large receptacle; and, being once diſcharged, frees the body from uneaſy ſenſation. The laſt drops, which remain in the lower part of the bulb, irritating by their weight, are expelled by the accelerator muſcle; namely, a ſtrong muſcular expanſion, placed round the bulb, whoſe fibres are diſpoſed in the ſhape of a feather, meeting together in the middle of the bottom-part of the bulb, and in their fore-part fixed by two tendons into the cavernous bodies of the penis, and in their back-part connected by three muſcular portions to the ſphincter of the anus, two of which portions may be alſo referred to the levators of the anus. This muſcle, when the ſphincter is firmly ſhut, draws the bulb upward; and, with a conſiderable force, alternately contracts the urethra, ſo as to expel the laſt drops of the urine.

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[173] The new muſcle of Santorinus, the depreſſor of the female urethra, which is produced from one ſide to the other.

DCCCIII. The pyramidal muſcle of the abdomen may be thought to draw the bladder downwards by the rope of umbilical veſſels, and likewiſe to relax it, and fit it for the action of the long muſcular fibres. But this cannot be admitted, ſeeing the muſcle itſelf is often wanting; neither can it bring down the bladder, and very rarely comes to the navel.

DCCCIV. But as the urine is ſharp, and the membrane of the urethra very ſenſible, and becauſe the air will likewiſe enter it; for theſe reaſons nature has ſupplied this canal with a large quantity of mucus. This mucus is generated not only from the ſources in the bladder, but more eſpecially from two conglomerate glandules; one of which is ſeated on each ſide in the angle, betwixt the bulb of the urethra and the cavernous body of the penis; from whence it ſends out a ſlender duct, running for a conſiderable length through the urethra. I am ignorant of any glandule of the iſthmus different from the cellular texture. Morover, the whole urethra is full of mucous ſinuſes, of a cylindrical figure; very many of which deſcend towards the glans, though ſome run in a contrary direction, having ſmall mucous cryptæ placed at their ſides, which depoſite there a fluid mucus, and diſcharge it into the urethra. A larger ſort of theſe mucous cryptæ are diſpoſed along the upper ſide of the urethra, beginning before the bulb, at the origin of the glans. There are others, ſtill ſmaller, mixed with theſe large ones, and placed laterally, and about the urethra. In women theſe mucous ciſterns are numerous and larger, which open into their much ſhorter urethra, more eſpecially at its opening.

DCCCV. The neceſſary cleanlineſs and avocations of human life require the urine collected to be diſcharged only at certain times. But theſe advantages could not be obtained without ſome danger of diſeaſe, from the depoſition of the earthy parts of the urine continually confined and at reſt; ſo that, by repeated additions of the like matter cemented together, a ſtone may be at length formed. But the plenty of mucus, with which the urinary paſſages are commonly defended, is, for the moſt part, a ſufficient guard againſt this diſorder, as we ſee the generality of people are free from the ſtone; unleſs the urine is more than commonly charged with an earthy, tartareous, or chalky matter, increaſed by the uſe of hard water full of ſelenitic matter[174], drinking wine, very viſcid food, inactivity of body, and a retention of the urine beyond the calls of nature; or ſome viſcid body capable of attracting the calculous matter; or finally, a diſorder of the kidneys, which might lay a foundation for the adheſion of the earthy matter.

CHAP. XXIX.

Of the GENITAL PARTS *in* MAN.

DCCCVI. THE veſſels belonging to the genitals conſtantly ariſe near the kidneys, and almoſt in all kinds of animals; by which nature ſeems to have intended a double uſefulneſs in one organ, which might be able to diſcharge the urine and ſemen, and to bear a relation likewiſe to the genital parts, though placed at a conſiderable diſtance, in a ſpace betwixt the tops of the thighs, and ſubſervient to cleanlineſs, modeſty, eaſineſs of birth, and the force of ſtraining in delivery.

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[174] The waters iſſuing from calcareous mountains, ſuch as thoſe of Gottingen, rarely generate calculi; they rather cure them: hence copious tea-drinking, and abſtinence from wines and pure generous liquors, are thought to be the primary guardians againſt the ſtone.

DCCCVII. The ſemen muſculinum is firſt formed in the teſticle; then repoſited in the ſeminal veſicles; afterwards ejected from the penis into the uterus, where it renders the female ovum prolific: and therefore this muſt be the order of our inquiry into theſe particulars. The human *teſticles*, but ſmall in proportion to the bulk of the body, are, in the fœtus, lodged within the abdomen behind the peritonæum; from whence, by degrees, they deſcend into the groins; and are at laſt, in a more advanced age, thruſt down below the groin, perhaps partly by their weight, and partly by the impulſe of the influent blood; yet ſometimes they are obſerved to remain behind in the groin of adults. They deſcend by a paſſage, which in the fœtus is open, cellular, and called the *proceſs*, leading from the cavity of the peritonæum into the ſcrotum; and the ſame paſſage, after the teſticle is tranſmitted, is contracted by a law of nature, and preſerves the teſticle[175].

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[175] The teſticles of man, from his firſt beginning, never appear in the ſcrotum, but are always, about the fourth, fifth, ſixth, or ſeventh month, found either in the lower belly, lying in the neighbourhood of the kidney, or fallen down towards the ring, or remaining in the groin; and at the end of the ſeventh, eighth, and ninth months, they get into the ſcrotum. But in ſome quadrupeds, as the elephant, according to Ariſtotle and Camper, they remain connected with the kidney during the whole courſe of life; and in the hedge-hog alſo, as Dr Hunter has obſerved, they are confined within the abdomen. The teſticles, then, we ſee, in man, ought to change their ſituation in time of pregnancy. While they yet remain near the kindeys, they are ſituated within the cavity of the peritonæum, which they lie near, and which in the ſame manner accompanies the ſpermatic blood-veſſels, and ductus deferens, ſituated without the peritonæum, to the teſticle, as it does veſſels to the cæcum: hitherto the teſticle is covered with no vaginal coat. With the lower part of the teſticle is connected the cellular net-work, leading through the ring towards the groins, called by the illuſtrious Hunter *gubernaculum*, whence they ſuppoſe the teſticle to be directed into the ſcrotum. From the cavity of the peritonæum a canal is formed as far as the ſcrotum, which during the deſcent of the teſticle is ſufficiently large; and when once the teſticle is down, forms a true continuation of the peritonæum, formerly known to Galen, de la Garanne, Camper, Hunter, &c. through which canal of the peritonæum parts of the in-

DCCCVIII. The teſticle is defended by various integuments; of which the firſt and outermoſt is that of the *ſcrotum*, made up of a cloſe cellular ſtratum, repleniſhed with veſſels, and cloſely adhering to the ſkin: which laſt has a kind of elaſtic or contractile motion at the approach of cold and in the act of venery, although without any muſcular fabric; yet it has commonly action enough to wrinkle the ſcrotum, and draw up the teſticles. This cellular coat, commonly called *dartos*, is placed round each of the teſticles ſeparately; by the conjunction of which together in the middle, is formed a kind of ſeptum, which appears more remarkable in a dry preparation; and this ſeptum is often imperfect in its upper part towards the penis.

DCCCIX. Within the dartos is ſpread a looſe cellular ſtratum, without any fat, except in the lower part of the ſcrotum, and may be inflated like the ſame ſubſtance in other parts. Next follows a muſcle, from its office called *cremaſter*[176]; which ariſes from the degenerating fibres of the leſs oblique muſcle of the abdomen, and from the tendon of the external obliquus, called by ſome a *ligament*, and ſometimes from other *fibres*, deſcending from the os pubis, and at length backward into a vagina, and, being ſpread every way, ſurrounding the teſticle, ſerves to compreſs, and to elevate it towards it contents.

DCCCX. Next to this follows the ſecond cellular ſtratum, whoſe ſpongy fabric is continued with the outtermoſt, that lies round the peritonæum; and this

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inteſtines and omentum may eſcape together, and join with the albuginea teſtis, unleſs this has already happened in the abdomen: hence the noted herniæ, not quite properly called *congenitæ*, ariſe. In general the abdominal aperture of this canal is ſhut after the deſcent of the teſticles: but it often remains quite open, or ſhut up with ſo ſoft a cellular texture as to yield to the omentum and inteſtines, when grown too fat, and in this way to produce hernias.

[176] You will find it moſt elegantly drawn in Camper's very uſeful plates of herniæ.

ſecond ſtratum is called *tunica vaginalis*[177]. In this the veſicles or cells of its fabric appear larger than elſewhere, and may be inflated one after another. At the beginning of the teſticle, above the epididymis, it is, in a manner, ſo ſeparated from the reſt above the teſticle, towards the rings of the abdominal muſcles, that the inflation can hardly be continued through. Betwixt this laſt membrane and the following is a ſpace, into which are exhaled thin vapours, and ſometimes a water is collected. The inner coat, called *albuginea*, is a ſtrong, white, compact membrane, which immediately inveſts and confines the proper ſubſtance of the teſticle itſelf.

DCCCXI. The teſticle more properly ſo called, is of an oval figure, with an acute vertex, looking upwards and a little outwards. The *epididymis* is a kind of additament to the teſticle; and is a flat ſubſtance, reſembling thick tape, which goes round the poſterior margin of the teſticle, to which it is connected by the cellular texture, and by blood-veſſels. In the lower part it is plain; on the upper part it adheres to the teſticle by a thick and convex head, as it does alſo on the lower part. In the middle, it is partly attached by its baſis, and being partly free makes a blind ſac.

DCCCXII. To the teſticle the *ſpermatic* arteries deſcend, one on each ſide ſent off by the aorta below the renal arteries; but not unfrequently from the renal arteries themſelves, from thoſe of the capſules, or from the aorta itſelf above the emulgents. This artery, the ſmalleſt in the body in proportion to its length, deſcends a long way outward before the pſoas muſcle, and gives ſmall branches to the fat of the kidney, to the ureter, meſocolon, glandules of the loins, and to the peritonæum; but more eſpecially towards the bottom of the kidney, it gives a remarkable branch inflected and covered with fat, yet leſſening itſelf, that takes a ſerpentine courſe behind the peritonæum, as far as the ring of the abdomen. This ring is formed entirely of the tendinous fibres, deſcending from the external oblique muſcle, interrupted in their oblique deſcent by a long aperture, growing wider downward; from this aperture part of the ſmaller inner fibres are broadly detached to the os pubis, and others croſſing cohere with the fibres beloning to the other ſide of the muſcle, which, being collected together, is called the *inner column.* Other ſtronger external fibres, diſtinguiſhed from the former by the aperture, are broadly inſerted by a thick bundle into the outer ſide of the os pubis, under the denomination of the *external column;* from whence various fibres run off to the faſcia lata and groin. The upper part of this opening is in ſome meaſure cloſed up by fibres, ariſing from the outer column, and aſcending in a curve direction round the inner and weaker column. Below theſe fibres there is a ſmall opening left, often ſeparated by tendinous fibres, thro' which deſcends the ſpermatic artery, with the vein, and vas deferens, with a good deal of cellular ſubſtance, by which they are wrapt together into a cylindrical cord; before the external column, through no perforation of the peritonæum, which it has every where lying on this fore part of it. At the baſis of this ring, the *ductus deferens* is joined with the rope of veſſels, and the whole bundle arrives at the groin, and thence at the ſcrotum. The ſpermatic artery gives many ſmall branches to the cremaſter, to the cellular coat, and to the ſeptum of the ſcrotum; and then deſcends in a double plexus, to the teſticle; of which the principal comes from betwixt the epididymis and origin of the vas deferens, at the middle and lower part of teſticle, and then goes, by tranſverſe branches, through the albuginea: the other plexus, that accompanies the vas deferens in the upper part of the teſticle, has a like termination, and is variouſly inoſculated with the former. There are other ſmall arteries, which go to the coverings of the teſticle from the epigaſtrics, and others from thoſe of the bladder, which follow the courſe of the vas deferens, both which communicate with the ſpermatic veſſels.

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[177] There are three coverings which ſurround the ſpermatic cord with the teſticle, known by the name of *vaginal tunics*. The common vaginal, which is the true continuation of the peritonæum; the proper vaginal coat of the cord, conſiſting of a looſer cellular membrane; and the proper vaginal coat of the teſticle.

DCCCXIII. Many of the ſmall arteries play about the epididymis; but the larger of them ſpread tranſverſely through the albuginea, which they perforate in ſeveral places, to enter the innermoſt fabric of the teſticle, through which they are minutely ramified in all points, and ſeparated by numberleſs membranous partitions. There is no large anaſtomoſis or communication betwixt the ſpermatic artery and vein here, any more than in other parts of the body; but ſome red blood is received into thoſe branches that paſs through the albuginea to the innermoſt ſubſtance of the teſticle. But from the long courſe of this artery, the ſmallneſs of its diameter, the number of ſerpentine flexures, the great ratio of the dividing branches to their trunk, and the coldneſs of their ſubcutaneous diſtribution, demonſtrate, that the blood flows not only in a ſmall quantity, but very ſlowly, to the teſticle.

DCCCIV. The *ſpermatic vein* of the right ſide is inſerted into the cava; but that of the left pours its blood into the emulgent vein, or into both; it is enormouſly larger than the artery, and takes the ſame courſe in company with that; but both its trunk and branches are much larger and more numerous, very ſerpentine, and formed into a bunchy plexus of conſiderable length, which is interwove with the artery, and continued as low as the teſticle, there by degrees dividing into two like the artery. There are ſome valves in this vein, but few.

DCCCXV. Theſe external coverings of the teſticle have ſmall arteries from the epigaſtrics; the ſcrotum from the crural arteries, with an internal branch, which are called the *external pudenda;* the fellow veins go to the ſaphena, and to the crural trunk.

DCCCXVI. The *nerves* of the teſticle are many, whence it has a peculiar tenderneſs of ſenſation; inſomuch that faintings and convulſions follow from bruiſing or injuring the teſticle, and particularly a conſtriction of the jaws. Some of them ariſe deep from the renal plexus, from the meſenteric plexus, from the trunk of the intercoſtal nerve, and laſtly from the meſocolic plexus, and follow the courſe of the ſpermatic veſſels. Others are proper to the ſurface of the coverings of the teſticle, from the ſecond, third, and fourth pair of the nerves of the loins.

DCCCXVII. I have frequently obſerved *lymphatic* veſſels in the ſpermatic cord, which are judged to ariſe from the teſticle itſelf, and mix themſelves with thoſe that accompany the inguinal blood-veſſels. The induſtry of late anatomiſts have traced them even to the network of the teſticle itſelf.

DCCCXVIII. The blood, moved ſlowly and in a ſmall quantity through the ſpermatic artery, by which it is brought to the inner fabric of the teſticle (DCCCXIII.), is there drained into very ſmall veſſels, which carry their fluids to the *ſeminal veſſels*, although we are ignorant of the manner by which the arteries communicate with theſe canals, the bundles of which form the whole ſubſtance of the teſticle. Theſe ſeminiferous veſſels are exceeding ſmall, ſerpentine, firm, or ſolid, and have a very ſmall light in proportion to their membranes; they are not, however, blind, as I have ſeveral times filled them through the vas deferens. They are collected together into bundles, about twenty in number, divided by diſtinct cells or partitions, which deſcend from the albuginea to conduct the arteries and veins. In each of theſe cells there is a ſeminiferous duct, to convey the ſecreted humour from the ſeminiferous vaſcules. Twenty or more of theſe ducts form a *net-work*, adhering to the ſurface of the albuginea, and forming inoſculations one with another; and quickſilver is very eaſily poured from them into the ſurrounding cellular texture. From that net in the upper part of the epididymis, aſcend twenty or thirty ducts, which, being contorted into folds, form as many *vaſcular cones*, that are joined together by an intermediate cellular ſubſtance; and lying incumbent one upon another, then form the head of the epididymis, and in that head ſoon meet together into one duct without the teſticle[178].

DCCCXIX. This duct being intricately wove by an infinite number of folds and ſerpentine flexures, after a manner not imitated in any other part of the body, and connected together by a great number of looſe cellular ſtrata, is afterwards collected by a membrane of the albuginea into one bundle, called the *epididymis*. But the duct of which it is compoſed, grows larger as it deſcends, being largeſt at the bottom of the teſticle; from whence again aſcending along the poſterior face of the teſticle, in a direction contrary to itſelf, it by degrees ſpreads its ſpiral convolutions, and comes out much larger, under the denomination of *ductus deferens*. Almoſt always, however, a ſmall veſſel ſeparates ſomewhere from the ductus deferens, and aſcends along with the cord, having an uncertain termination.

DCCCXX. This is the courſe deſcribed by the ſemen, propelled forward by the motion of the ſuceeding juices in the teſticle; and perhaps, in ſome meaſure, though ſlowly, by the contraction of the cremaſter: as we may reaſonably ſuppoſe, from the numberleſs ſpires and convolutions formed by the epididymis, obructing almoſt every kind of injection; and, as we may conclude, from the length of time that is required to fill the ſeminal veſicles again, after they have been once exhauſted.

DCCCXXI. The cylindric ductus deferens being made of a very thick ſpongy ſubſtance, included betwixt two firm membranes, bored through with a very ſmall tube, aſcends in company with the cord of the ſpermatic veſſels, and together with them paſſes through the ring of the abdomen (DCCCXII.): thence it deſcends into the pelvis; and applying itſelf to the bladder betwixt the ureters, it ſoon after meets the ſubjacent receptacles, called the right and left *veſiculæ ſeminales*. Here it goes along the inner ſide of the veſicle, as far as the proſtate glandule; and dilating in its paſſage, forms a ſerpentine flexure, that begins itſelf to put on a cellular appearance. But very near the proſtate, being continued from theſe cellular bendings, with a conical duct coming out from the veſicle, it unites in a very acute angle, which does at the ſame time itſelf form a conical duct; which being continued rather with the vas deferens, and ſinking through the proſtate gland, is there wrinkled into a large fold, and going off outward at right angles from its companion on the other ſide, and afterwards ſtraitened, it opens into the urethra, thro' a little hollow protuberance, which has a long tail or deſcent, and is laterally perforated with two very ſmall openings, one on each ſide. By injecting a liquor into the ductus deferens of a dead ſubject, we perceive that it flows both into the urethra and into the ſeminal veſicle, but more readily into the former: but in a living perſon the ſemen never flows out but in the act of venery; and conſequently the ductus deferens conveys all its ſemen, without further delay, over a retrograde angle, to the *ſeminal veſicles*.

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[178] This every obſervation confirms: but I have often ſeen the number of the cones greater. Fontana ſays they have been as many as thirty-ſeven: and the celebrated Monro long ago demonſtrated, that they vary differently in different perſons.

DCCCXXII. By this laſt denomination we call a ſort of ſtrong convoluted inteſtine-like membrane, placed under the baſis of the bladder, connected towards its neck by a good deal of cellular ſubſtance: from this ten or more blind gut-like cells or inteſtinuli go off laterally, in ſome meaſure ramified and divided, but ending in impervious conical extremities. This kind of inteſtine, intermixed with a great deal of firm cellular ſubſtance and ſmall veſſels, is ſo contracted, as to lie within a ſhort ſerpentine heap. For the reſt of its fabric, it ſeems to have externally a pulpy and thick membrane, and likewiſe ſomething ſimilar to the ductus deferens. Internally it is wrinkled, having a ſort of villous appearance; and is beſides ſaid to have ſmall pores and glandules, with which I am unacquainted, but various and hollow cells it certainly has.

DCCCXXIII. The liquor depoſited into this reſervoir, is in the teſticle yellowiſh, thin, and watery: and the ſame nature it retains in the veſicle, only becomes there ſomewhat thicker and higher coloured; and laſtly, it is white in mankind, when it has mixed with the liquor of the proſtate. It has a ſort of heavy or ſtrong ſmell, of a peculiar kind in each claſs of animals; and it is the heavieſt humour in the human body. In water, however, a part goes off into a kind of cuticle, like a cobweb, that ſwims in the liquid; the greater part, which is ſeemingly of a pulpy nature, falls to the bottom. In the ſemen which is long kept by chaſte people, ſhining globules mixed with the white liquor are eaſily to be ſeen. It has a very great quantity of mucus.

DCCCXXIV. Without the conveyance of this into the womb, no claſs of animals, of which there are two ſexes, can be fecundated ſo as to propagate their ſpecies. The reaſon of this was concealed from us, till the microſcope taught, that in man, as well as in all other male animals, the ſeminal liquor is full of living animalcules, reſembling eels, only with a thicker head; and that theſe are always preſent in healthy ſemen, from the time that a perſon comes of age; but, before that time, and in thoſe who are ſterile from a gonorrhæa, they are abſent[179]. That they are animacules, appears evidently from their various motions, reſtings, and geſtures of body.

DCCCXXV. It has been much doubted what could be the uſe of theſe animalcules; and in another place we ſhall conſider the diſpute concerning the opinion that they are as it were the firſt appearance of the future animal. To me, in the mean time, the nature of the ſeminal animalcules ſeems to be the ſame with that of the eels in vinegar or paſte.

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[179] A very few authors excepted, all agree, that there are animalcula in the ſemen of the more perfect animals; as has been ſhown by the elegant obſervations of Ham, Leuenhoeck, Hartzoeker, more than theſe hundred years; which, alſo the labours of the famous Lieberkuhn, Leidermuller, Burgrav, Gleuhen, and Spallanzani, have confirmed, and demonſtrated all their attributes.

DCCCXXVI. That the ſemen is produced from the lymph of the blood, and that the chyle is added to the lymph, will appear probable from the ſudden alacrity to venery that happens after eating, and which is leſſened by faſting. It is compounded of the liquor of the teſticles and ſeminal veſſels, the former indeed being more evident in ſome animals, and the coagulable milk of the proſtate gland. That liquor, however, only fecundates which is generated in the teſticles; as we ſee from geldings, which, though they have the ſeminal veſſels and proſtate, are yet barren.

DCCCXXVII. The ſeminal fluid is retained in the veſicles as long as a man neither exerciſes venery, nor ſports in imaginary dreams. But it is always a ſtimulus to the animal appetite of venery, as long as it is there preſent in any quantity. But beſides this, there is a conſiderable ſtrong, volatile, and odorous part of the ſemen abſorbed again into the blood, where it produces wonderful changes as ſoon as it begins to be formed; ſuch as the protruſion of the beard, the covering of the pubes, a change of the voice and paſſions, horns in cattle, &c. for theſe changes in the animal are not the conſequences of age, but of the ſeminal fluid, and are always abſent in eunuchs. The growth and ſtrength of caſtrated animals are conſtantly diminiſhed; and in like manner the fierceneſs of their temper, and the ſtrong ſmell of their whole body, are remarkably weakened. And from the examples of ſome animals, and even of mankind, it appears, that the irritation of this fluid has occaſioned death, by exciting convulſions. A retention of the ſemen may follow from a narrowneſs of the excretory duct, a ſcirrhoſity of the proſtate, and other cauſes not ſufficiently known.

DCCCXXVIII. The quantity of ſemen expelled at one time from the human veſicles is but ſmall, more eſpecially in a man who has not long abſtained from venery;

nery; and it is natural to think that the liquor can be but ſlowly produced from ſo ſmall a ſubcutaneous artery. Its generation is accelerated by love, by the preſence of the beloved woman; ſo that it diſtends its veſſels with a ſenſe of pain. Nature herſelf, therefore, enjoins venery, both for preſerving the human race, and likewiſe the health of every ſound man. That it comes from the teſticle, is ſhown by diſeaſes, in which the ductus deferens being obſtructed, a ſwelling of the teſticle has enſued. The veſicles never are emulged, except by venereal actions and appetites.

DCCCXXIX. Seeing the ſemen is in ſmall quantity, that it might be projected with a greater force, and to a farther diſtance, nature has joined another humour, which is generated by the *proſtate*. This is a gland, ſhaped like a heart, with the ſmall end foremoſt, ſo as to ſurround the organ of the urethra, but moſt round its upper ſide. This is one of the hardeſt and moſt compact glands, of a peculiar fabric, yet not evidently conglomerate; it prepares a thick, white, ſoft, or cream-like liquor in a large quantity, which is poured out at the ſame time and from the ſame cauſes (DCCCXL.) with the ſemen itſelf, into a little valley or channel at each ſide of the openings of the ſeminal veſicles, where, mixing with the ſeminal fluid, it imparts the white colour and viſcidity which the ſemen poſſeſſes.

DCCCXXX. But it was neceſſary for this canal of the urethra to be firm and capable of a direct figure, that it might be able to throw the ſemen with ſome ſtrength into the diſtant womb; and therefore a three-fold cavernous body ſurrounds it. The firſt and proper cavernous body of the urethra begins, as ſoon as that canal has paſſed the proſtate, with a thick origin, almoſt like a heart, firſt under the urethra, and then above it, but thinner; from thence it ſurrounds the whole canal, through the whole length of the penis, till the lower part terminates in the glans, while the upper part is reflected from the extremity of the urethra, and, being dilated, returns in a direction contrary to that of the penis, which being circumſcribed by a broad circumference, gradually extenuated, and ſomewhat round, terminates the extremities of the cavernous bodies, upon which it is incumbent, and with thoſe for the moſt part communicates by an imperfect ſeptum. The fabric of this body is cellular, but of a larger ſort than the cells of the cavernous bodies, being compoſed rather of plates than fibres, interwoven like a net, and intercepted betwixt two firm membranes.

DCCCXXXI. Into this cavernous body of the urethra, the blood is poured out from the arteries, which come from deep branches ſent off from the external hæmorrhoidals (DCCCXXXVI.); the truth of which is demonſtrated by the injection of any kind of fluid, which, being urged into the ſaid arteries, eaſily flows into theſe cellular ſpaces ſurrounding the urethra. But theſe are not naturally turgid with blood, becauſe there are veins open and numerous enough in proportion to drink up and return what is poured in by the arteries; but if the return is impeded by compreſſing thoſe veins from the powers hereafter mentioned (DCCCXXXIX.), the blood is then retained within the cellular ſpaces, while the arteries continue to import it more ſwiftly and ſtrongly than the veins return it. Thus the ſtagnant blood diſtends the bulb of the urethra, together with its cavernous body, and the glans itſelf. But this is performed generally at the ſame time, when the other cavernous bodies of the penis, with which this of the urethra has no communication, are likewiſe rigidly diſtended.

DCCCXXXII. But the cavernous bodies of the penis ariſe from the oſſa iſchii and pubis, where they are conjoined by a white, cellular, very denſe, and firm ſubſtance; from whence inclining inward towards each other, they take betwixt them the urethra, a little before its bulb, where, changing their direction, they go on parallel, conjoined together, and with the urethra extended forward along their middle, and terminate with an obtuſe end in the glans, and laterally they are comprehended by the cavernous body of the urethra. Theſe bodies are covered with a very firm integument, and their internal fleſh is ſpungy, like that of the urethra (DCCCXXX.), like which it is capable of being diſtended by the reception of the blood. Betwixt both cavernous ſacs there is a middle ſeptum or partition, compoſed of firm parallel tendinous fibres, growing narrower downward; but not continuous one to another, that the intermediate ſpaces might be larger and more numerous as they are more forward, and that they might leave a free communication betwixt the right and left ſpungy body. Other ſuch robuſt fibres run through the cavernous bodies, and are very firmly inſerted into the ſides of their membranous ſac, ſo as to prevent an aneuriſm or over-diſtention of the penis.

DCCCXXXIII. Theſe cavernous bodies are ſurrounded with a good deal of very tender cellular ſubſtance; of which that ſide lying next the cavernous bodies is denſe and firm, like a membrane; but from thence outward, towards the ſkin, its fabric is cellular and very tender, without including any fat, and continuous with the cellular membrane of the ſcrotum, but always the more tender the nearer the ſkin it is; and, by blowing air into it, it appears to have a fine ſilky texture. But the glans (DCCCXXX.) is naturally covered in ſuch a manner, that the ſkin is continued from the penis, and folded back againſt itſelf, as we obſerve in the eye-lids; both folds of the ſkin being covered with its proper cuticle, and ſtuffed, each with its proper cellular ſtratum, under the name of *preputium*, or prepuce; which may be, like a cap, drawn back from, and again brought over, the glans; at which it changes into a tender papillary body, vehemently ſenſible, covered with its proper cuticle and cellular ſubſtance, ſpread over the reflected cavernous body of the urethra (DCCCXXX.); and, finally, is continued with the membrane of the urethra itſelf. The ſaid prepuce is tied by a double triangular ligament, by which the common ſkin is conjoined to that which makes the covering of the glans. Upon the excavation that ſurrounds the crown of the glans, as well as upon the crown itſelf, are ſeated ſimple ſebaceous follicles, which ſeparate a liniment of a peculiar, ſomewhat fetid ſmell, from the nature of their ſeat, ſerving to abate the attrition of the ſkin, as in other parts of the body. Finally, the whole body of the penis is ſuſtained by a firm cellular plate, compacted into a kind of triangular ligament, which deſcends from the ſynchondroſis of the oſſa pubis, and is from thence continued into the denſe cellular ſtratum that ſurrounds the hard cavernous bodies.

DCCCXXXIV. The whole human penis forms a cylindrindrical body, depreſſed on the upper part, of variable magnitude; whoſe uſe is, to be received into the female parts of generation, and to carry thither prolific ſemen.

DCCCXXXV. Theſe cavernous bodies then of the penis, having their ſpungy fabric diſtended in coition by the blood retained by the veins, and ſtill propelled by the arteries, become rigidly turgid, and ſuſtain the otherwiſe flaccid or but weakly filled urethra, in ſuch a manner that it may be able to conduct the ſemen into the diſtant womb. All this is demonſtrated from the diſſection of brute animals in the act of venery, from an artificial erection, and from the injection of liquid matters into the veſſels of the penis. The cauſe is love, the deſire of pleaſure, the friction of the glans, various irritations of the bladder, teſticles, ſeminal veſſels, urethra, from the urine, from abundance of good ſeed, from the venereal poiſon, from cantharides, whipping with rods, or convulſion of the nerves. But the cauſe of this diſtention remains ſtill to be explained. The diſtribution of the blood-veſſels into the genital parts are therefore to be here deſcribed, to make it evident, how ready the compreſſing cauſe conſtantly is to act upon the veins.

DCCCXXXVI. The aorta at the fourth vertebra of the loins, and the vena cava at the fifth, are divided, the former before the latter. The common iliac branches, not yet arrived to the middle of the interval in the thighs, ſend off inward and downward a conſiderable artery, called the *hypogaſtric*, which in the fœtus is larger than the femoral artery, and in the adult is equal to it. This deſcending into the pelvis, divides into four, five, or ſix principal branches; of which the firſt is the *iliaca anterior*, which ſupplies branches upward to the dura mater, cauda equina, and loins, and afterwards into the os ſacrum. The next, or *ſacro-lateral* artery, goes off from the bone of that name, when it does not ariſe from the former; and the third, or *iliaca poſterior*, is diſtributed to the glutei muſcles. The fourth, the *iſchiatica deſcendens*, goes to ſeveral muſcles, nerves, and levators of the anus. The fifth trunk is that of the *hæmorrhoidea infima* or *pudenda communis*, which in the cavity of the pelvis ſends conſiderable branches to the bladder, and to the rectum gives the middle hemorrhoidal joined with the meſenterics; after which, going out of the pelvis, it creeps by the ſide of the obturator, and gives off the *external hæmorrhoidals* to the ſphincter and ſkin of the anus: then dividing, it goes with an internal branch to the bulb of the urethra and ſurface of the proſtate, where the external is again divided: here it enters deeply the cavernous body of the penis, and runs through its whole length; while by another branch often joined with the veſſels of the bladder, it runs along the back of the penis, according to the direction of its bodies, and terminates with them by ramifications into the ſkin. The ſixth is the *obturatrix*, ſpent upon the joint of the femur and adjacent muſcles. The laſt is the *umbilical artery*, to be deſcribed in treating of the fœtus; although in adults it ſends off ſome branches to the bladder, from its thick callous vagina. Sometimes one or more of theſe arteries come from the common trunk. The ſkin of the penis and ſcrotum have their arteries from the epigaſtric, and from the internal branch of the crural. Theſe external arteries communicate in many places with the internal.

DCCCXXXVII. The *veins* are, in general, diſtributed in like order with the arteries. They come off in two trunks from the iliacs, joining together into a net; and then the *hæmorrhoidal* vein, bending round under the os pubis, forms a large plexus, ſpread with the veins of the pelvis upon the proſtate and ſeminal veſicles: from hence the *vena penis* ariſes, which is often ſingle, and furniſhed with valves to forward the return of the blood. The external veins of the penis and ſcrotum go to the ſaphena and crural, communicating in ſeveral places with the internal veins, more eſpecially at the baſis of the prepuce.

DCCCXXXVIII. *Lymphatic veſſels* of the penis are, by moſt eminent anatomiſts, ſaid to run under the ſkin towards the groins. The *nerves* of this part are both numerous and very large, and accompany the arteries of the penis from the trunk of the great ſciatic nerve[180]. But the bladder, rectum, and uterus, are ſupplied by the *lower meſenteric* plexus, which ariſes from the middle one, deſcending into the pelvis.

DCCCXXXIX. In order to diſtend the penis, there muſt be either a compreſſure of the vein (DCCCXXXIV.), bringing back the blood from the cavernous bodies of the penis or urethra; or at leaſt it is neceſſary that there be a conſtriction of the leſſer veins that every where open within the cavernous bodies, to hinder them from abſorbing and returning the blood from the arteries. The firſt, however, may be effected by the levator, drawing up the proſtate and bladder: but it is very probable, that, as we ſee in the nipples of the ſuckling mother, in the gills of the peacock, and in the bluſhing or redneſs of the face from paſſions of the mind, as well as from brute animals, which all couple without the uſe of any erector muſcle; from the erections which take place in animals totally different from man, and eſpecially thoſe which take place in birds very quickly; from the reſt of the erector muſcles themſelves in the libidinous erection of the penis, and from their unfitneſs for compreſſing the veins; from all theſe, I ſay, it is probable, that the courſe of the blood through the vein may be retarded, without the immediate uſe of any muſcle; and that, by the power of the numerous, ſmall, latent, nervous bridles, by whoſe conſtriction, from the force of pleaſure, the veins are compreſſed and ſtraitened, ſo as to return leſs blood to the trunks, at that time, than what is imported by the arteries, which are not only free from any ſtricture, but, by the increaſe of pulſation bring a greater quantity of blood, which cauſe alſo contributes to produce the erection. But the cauſe of this conſtriction in the nervous bridles or ſphincters themſelves depends upon a mechanical irritation of the nerves, and from ſomething more ſubtile, by which means the penis is immediately erected.

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[180] The bundles of the nerves of the penis are numerous and great, equalling almoſt the ſenſitive organs. The ſuperior ones have a double origin; the common plexus of the perinæum ariſes from the iſchiadic plexus, which produces the great dorſal nerve of the penis, that is diſtributed between the ſkin and lateral part of the corpora cavernoſa, as far as the gland itſelf: the inferior ſerve both the penis and ſcrotum.

DCCCXL. A long continued and violent erection is at laſt joined commonly with an expulſion of the ſemen; and this requires much greater force than is requiſite for the erection only. For the ſemen follows at that time when the irritation of the nerves is arrived at its greateſt height: and in natural venery indeed, when at length the cellular ſpaces of the urethra and its continuous glands, which are at laſt filled, become ſo far diſtended with a large quantity of warm blood, that the nervous papillæ, ſtretched out in the latter, become violently affected from the irritating or pleaſing cauſe; the ſeminal veſicles are emptied by the levator muſcles of the anus, which preſs them againſt the reſiſting bladder with a convulſive motion, excited either by a voluptuous imagination, or from the pruritus that is exquiſite in the nerves of the glans, principally in its lower part, which is in the neighbourhood of the frenum. Hence the ſemen is never diſcharged with any of the urine, in an healthy man; becauſe the expulſion of it requires the bladder to be cloſed or drawn up firmly together; for, while lax, it affords little or no reſiſtance to the ſeminal veſicles. The tranſverſe muſcles ſeem to dilate the canal of the urethra for the reception of the ſemen expreſſed from the veſicles.

DCCCXLI. Soon afterwards the powers conſtringing the urethra are, from the irritation of the very ſenſible fabric of that canal, put into action. To this conſtriction conduces principally the accelerator (DCCCII.), which makes a powerful concuſſion of the bulb and adjacent part of the urethra, ſo as to propel the contents more ſwiftly, in proportion as the bulb has a larger diameter than that of the urethra. But that this may act firmly, the ſphincter of the anus, together with that of the bladder, muſt be well ſhut. The accelerator muſcle ſeems alſo principally concerned in the erection, by compreſſing the veins of the corpus cavernoſum of the urethra. At the ſame time the *erectores penis*, as they are called, ariſing from the tubercles of the iſchium, become ſtrong, and are inſerted into the cavernous bodies, ſuſtaining the penis as a ſort of medium betwixt the tranſverſe and perpendicular direction. Thus the ſemen is drove into the vagina, and into the uterus itſelf, in a prolific coition: the whole action of which is very impetuous, and comes near to a convulſion; whence it wonderfully weakens the habit, and greatly injures the whole nervous ſyſtem, as the maladies ariſing from thence ſeem to indicate, in conſequence of the affection of the nerves, without which the ſemen cannot be expelled.

CHAP. XXX.

Of the VIRGIN UTERUS.

DCCCXLII. THE *uterus* is ſeated in the upper part of the pelvis, with the bladder before, and the rectum behind it, without adhering to either of them, and has its mouth turned a little forwards. In an adult woman, it is contained within the pelvis; but in an infant, it lies above it. In women, the peritonæum deſcends from the os pubis into the pelvis, over the poſterior face of the bladder, down to the bottom or mouth of the uterus: from whence again it aſcends over the foreſide of the uterus; and paſſing round its convexity, deſcends on the poſterior ſide down to the vagina, from whence it extends laterally or tranſverſely on each ſide, including the rectum with lunated folds, which is all the difference betwixt the female and male peritonæum. But this ſame peritonæum, coming into the pelvis from the iliac veſſels, and broadly adhering to the ſides of the uterus and vagina, is folded back over itſelf, and divides the pelvis into two parts, the anterior and poſterior, like a partition, under the denomination of *ligamentum latum.* Thus the peritonæum accurately connects the uterus, without the intervention of any fat, ſo as to ſerve it on all ſides as an external coat or covering. It does not, however, hinder the uterus from being totally free and moveable.

DCCCXLIII. The body of the uterus is uſually diſtinguiſhed from its neck. The body is flatly convex before and behind, with acute edges on each ſide and at the meeting of its convexities, but converging gradually afterwards for ſome way; in its upper part, moderately convex. It has a peculiar fabric, being made up of a cloſe, firm, but ſomewhat ſucculent and cellular fleſh, in which we perceive the appearance of muſcular fibres, more eſpecially in thoſe women that have born children: ſome of which fibres are flat, and mixed with one another into a kind of net-work; others run along the uterus longitudinally, from the bottom to the mouth of the uterus, diſpoſed in various circles, and particularly at the fundus betwixt the tubes, and likewiſe in the neck near the mouth. In beaſts, the uterus is manifeſtly muſcular; and in women, likewiſe, gives evident ſigns of a contractile power. Its outer coat is received from the peritonæum. As for any mucous ſinuſes variouſly branching and dividing within the fleſh of the uterus, after repeated inquiries we now declare, that we have not been able to find any; only ſome veins, ſurrounded with cellular ſubſtance, by which their diameters are ſuſtained. The internal membrane of the uterus is continued from the cuticle; in the upper part of the cavity fleecy; and in the lower part callous, and valvular. The cavity of the uterus is ſmall, for the moſt part triangular upward, and below like a compreſſed cylinder. The cylindric part, which is called the *cervix* or *neck*, is compreſſed, thick, and has alſo a cylindric cavity within. It is altogether rough, with callous wrinkles riſing up into an edge; whence they incline towards the vagina. Theſe recede laterally from the anterior and poſterior margin, joining together by ſmall wrinkles, in the intervals of which are ſmall mucous ſinuſes, with ſmall pellucid ſpherules, filled with a very clear liquor, in ſome parts interſperſed through the upper region of the cervix uteri, differing both in their number and magnitude. It is not uncommon for the uterus to be diſtinguiſhed by a line or protuberance extended through its middle. The cervix is terminated by the os internum uteri, with a tranſverſe rim, forming protuberant lips, which project for ſome length into the vagina, are received by its blind extremity, and project into it obliquely forward. But it is full of mucus, and mucous ſinuſes ſituated in its ſwelling lip.

DCCCXLIV. The triangular part of the uterus ſends out, from its lateral angles, canals, in ſome meaſure folded together by the cellular ſubſtance, growing gradually broader, and being again a little contracted towards their extremity, they proceed towards the ovary, firſt in a tranſverſe direction, and afterwards a little deſcending, but with ſome variation, under the denomination of the uterine *tubes*. Their external membrane is from the peritonæum: for they are included within the duplicature of the broad ligament, which is a production of that membrane; internally they are wrinkled almoſt reticularly, lined with mucus, extended to a conſiderable length by intervening plates or folds which broadly crown the opening of the tube, which is alſo connected to the ovary. Betwixt the two membranes is ſomething of a ſpungy cellular ſubſtance, of a ſlender texture. They alſo contain uſually a mucus, the origin of which is not known. There are alſo great numbers of veſſels, and perhaps ſome muſcular fibres, but the latter are more obſcure. They are ſupported by the proper fold of the peritonæum which goes out from the broad ligament.

DCCCXLV. But the *ovaries*, included in the ſame duplicature of the broad ligament behind the tubes, are ſeated tranſverſely, and conjoined to theſe tubes by a ligamentary expanſion of their own, which is long enough to allow them a free motion. They are ſomewhat of an oblong or oval figure, depreſſed on each ſide, convex upon their unconnected ſide, and half elliptical; but that which is connected with the ligament is ſtraight. Their membrane, which comes from the peritonæum, is thick, and almoſt cartilaginous. Their fabric nearly enough reſembles that of the uterus itſelf; being a cloſe, white, cellular ſubſtance, compacted together, without any fat. The margin of the broad ligament, receding from the uterus to ſuſtain the ovary, has ſomething of a more ſolid and thick ſubſtance, reſembling a ligament, yet is not a hollow or true canal.

DCCCXLVI. But in the ovary even of a tender virgin, are ſituated round veſicles made of a pretty ſtrong pulpy membrane, connected every where to the ovarium by cellular threads, which are filled with coagulable lymph; of an uncertain number and magnitude, being found in one ovary to fifteen and upwards. Theſe remarkable bodies are found very widely diffuſed thro' all animals, even ſuch as have but one ſex.

DCCCXLVII. Laſtly, the uterus ſends out from the ſame lateral angles of its triangular body downward, a kind of faſciculus, compoſed of long cellular fibres and ſmall veſſels [181], which, becoming ſmall in its progreſs, goes out of the pelvis through the ring of the abdomen (DCCCXII.) into the groin, where it ſplits into branches, and diſſolves into ſmall veſſels, which communicate with the epigaſtrics. Whether or no it has any long fibres propagated from the uterus itſelf, does not plainly appear.

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[181] They grow to a remarkable ſize during pregnancy, along with the other ſpermatic and uterine veſſels; and this bundle abounds with many lymphatic veſſels, which is called, though not very properly, *teres ligamentum uteri*. Dr Hunter has given an excellent drawing of it.

DCCCXLVIII. The arteries of the uterus are from the hypogaſtrics; a conſiderable branch of which goes off, like that to the bottom of the bladder in men; or at leaſt it ariſes from the umbilical trunk, or immediately below that trunk, and makes the common artery belonging to the uterus, bladder, and rectum. It ſpreads on the lower parts of the uterus, almoſt at the extremity of its neck; and, aſcending upwards, ſends tranſverſe inflected branches to the uterus, makes numerous anaſtomoſes with the ſpermatics, and often gives arteries to the tube itſelf. Another plexus of branches tends downwards to the vagina, and follows it a long way; although there is otherwiſe a proper vaginal artery originating in the pelvis, and branches ſometimes come from the meſocolic. There are alſo ſeminal veſſels which have the ſame origin as in men; and form a plexus, which, from its ſimilitude to the tendrils of a vine, is called *pampiniformis*. This plexus, deſcending over the pſoas muſcle into the pelvis, divides into two plexuſes. The poſterior ſurrounds the ovary itſelf, with many circles, elegantly diſtributed through its ſubſtance and the ova themſelves. The anterior both ſupplies the tube, and deſcends to the uterus itſelf, in which it ſends out winding branches upward and downward, and ſome branches that are detached to the bladder. Another artery is the middle hæmorrhoidal, coming from the common trunk of the pudendal, a conſiderable way forward with the vagina; to which, and to the bladder and rectum, it is diſtributed. The beginning of the vagina likewiſe, and the clitoris, have arteries from the external hemorrhoidal, which are diſtributed like thoſe of the penis, ſome inwardly, others ſu-

ſuperficially, both of which inoſculate with the veſical branch.

DCCCXLIX. The courſe of the uterine veins is like to that of the arteries, originating from the trunks of the hypogaſtrics; they are the internal uterine, the vaginal, the middle hemorrhoidal, the external circumflex, and thoſe of the clitoris. But they make a remarkable plexus on each ſide, which occupies the ſides of the vagina below the clitoris. Below that, it is joined into a continued plexus with its companion on the other ſide. A plexus alſo from the external hemorrhoidal, and joined with the veſical veſſels, goes to the clitoris, as well as to the penis. It has no valves, except a few in the ſpermatics. Theſe, in a very large bundle, go to the ovarium, and alæ veſpertilionis.

DCCCL. Within the uterus itſelf the arteries terminate in exhaling branches on its internal cavity. By childbirth theſe go off into little pendulous productions, like very ſmall eels. Thus the veins of the uterus are at the ſame time very large ſinuſes; for the veins are enormouſly augmented, and open with very large mouths into their cavity.

DCCCLI. Lymphatic veſſels are found in the uterus of brutes, but more rarely in the human; they have been obſerved, however, by very eminent anatomiſts.

DCCCLII. The nerves are ſupplied from the lower meſocolic plexus, united with thoſe of the ſacrum, which ſends out large branches to the bladder, womb, and rectum; beſides which, there are a few nervous twigs that deſcend through the broad ligament to the ovaries, and others from the nerve that goes with the veſſels to the clitoris. But the ovary has alſo its proper nerves from the renal plexus, ſimilar to thoſe which go to the teſticles of the male. The great number of the nerves, therefore, make theſe parts extremely ſenſible.

DCCCLIII. The deſcriptions we have hitherto given, are in common to all ages of the female; but about the 13th year, or ſomewhat later, nearly at the ſame time when ſemen begins to form itſelf in the male, there are likewiſe conſiderable changes produced in the female. For at this time the whole maſs of blood begins to circulate with an increaſed force, the breaſts ſwell out, and the pubes begins to be cloathed: at the ſame time the menſes in ſome meaſure make their appearance by a common law of nature, although in different countries both the time and quantity of the flux is different.

DCCCLIV. But, before the menſtrual flux, there are various ſymptoms excited in the loins, heavy pains, ſometimes like colic pains, with an increaſed pulſe, headachs; and cutaneous puſtules commonly precede, and a white juice commonly flows from the uterus. For now the fleecy veſſels of the uterus, which in the ſtate of the fœtus were white, and tranſuded a ſort of milk, as in the young girl they tranſuded a ſerous liquor, do now begin to ſwell with blood; the red parts of which are depoſited through the veſſels into the cavity of the uterus. This continues ſome days, while in the mean time the firſt troubleſome ſymptoms abate, and the uterine veſſels, gradually contracting their openings, again diſtil only a little ſerous moiſture as before. But then the ſame efforts return again at uncertain intervals in tender virgins; till at length, by degrees, they keep near to the end of the fourth week; at which time follows the flux of blood, as before, which is periodically continued to about the 50th year; though the diet, country, conſtitution, and way of life, cauſe a great variation in this diſcharge. Pregnancy commonly produces a temporary ſtoppage of the menſes.

DCCCLV. This diſcharge of blood from the veſſels of the uterus itſelf, is demonſtrated by inſpection in women who have died in the midſt of their courſes; and in living women, having an inverſion of the uterus, the blood has been ſeen plainly to diſtil from the open orifices: in others, in whom, when the menſes have been deficient, the uterus has appeared full of concreted blood. It alſo appears from the nature of the uterus itſelf full of ſoft ſpungy veſſels, compared with the thin, callous, by no means fleecy, and almoſt bloodleſs ſubſtance of the vagina. That this is good blood in an healthy woman, appears both from the foregoing and innumerable other obſervations. Nevertheleſs nothing hinders the blood from being ſent forth through the vagina, as in other caſes it is through the inteſtinum rectum, and in ſhort through the remoteſt parts of the body.

DCCCLVI. Since none but the human ſpecies are properly ſubject to this menſtrual flux of blood (altho' there are ſome animals who, at the time of their vernal copulation, diſtil a ſmall quantity of blood from their genitals), and ſince the body of the male is alway free from the like diſcharge, it has been a great inquiry in all ages, what ſhould be the cauſe of this ſanguine excretion peculiar to the fair ſex. To this effect the attraction of the moon, which is known to raiſe the tides of the ſea, has been accuſed in all ages; others have referred it to a ſharp ſtimulating humour, ſecreted in the genital parts themſelves, the ſame which is the cauſe of the venereal diſeaſe. But if the moon was the parent of this effect, it would appear in all women at the ſame time; which is contrary to experience, ſince there is never a day in which there are not many women ſeized with this flux; nor are there fewer in the decreaſe than the increaſe of the moon. As to any ſharp ferment ſeated in the uterus or its parts, it will be always inquired for in vain; where there are none but mild mucous juices, and where venery, which expels all thoſe juices, neither increaſes nor leſſens the menſtrual flux: and women deny that, during the time of their menſes, they have any increaſed deſire of venery; ſeeing at that time moſt of the parts are rather pained, and languid; and the ſeat of venereal pleaſure is rather in the entrance of the pudendum than in the uterus, from which laſt the menſes flow. But, laſtly, that the menſtrual blood is forced out by ſome cauſe exciting the motion of the blood againſt the veſſels, appears from hence, that, by a retention, the courſes have been known to break through all the other organs of the body, where no vellicating ferment could be ſeated, even ſo as to burſt open the veſſels of each organ; and that the effect produced by the retention of the blood, is not confined to thoſe parts which pour out the venereal humour.

DCCCLVII. Nature has, in general, given women a more delicate body, and ſolids that are leſs elaſtic; their muſcles are alſo ſmaller, with a greater quantity of fat interpoſed both betwixt them and their fibres; the bones too are ſlenderer, and their ſurfaces have fewer proceſſes and aſperities. Moreover, the pelvis of the female is, in all its dimenſions, larger; the oſſa ilia ſpread farther from each other; and the os ſacrum recedes more backward from the bones of the pubes, while the oſſa iſchii depart more from each other below; however, the angle in which the bones of the pubes meet together to form an arch, is in the female remarkably more large; which differences are confirmed by the obſervations of the great anatomiſts; and from neceſſity itſelf, which requires a greater ſpace for a greater number of viſcera in the pelvis. Moreover, the uterine arteries are conſiderably large, more ſo than in men; and have a greater proportion of light, with reſpect to the thickneſs of their coats: but the uterine veins are, in proportion, leſs than in men; and of a more firm reſiſting texture, than in other parts of the body. From hence it follows, that the blood, brought by the arterial trunk to the womb, by paſſing from a weaker artery into a narrow and more reſiſting vein, will meet with a more difficult return, and conſequently diſtend the uterine veſſels.

DCCCLIX. The female infant new-born has her lower limbs very ſmall; and the greater part of the blood, belonging to the iliac arteries, goes to the umbilicals, ſending down only a ſmall portion to the pelvis. Hence the pelvis is ſmall, and but little concave; ſo that the bladder and uterus itſelf, with the ovaries, project beyond the rim of the pelvis. But when the fœtus is born, and the umbilical artery is tied, all the blood of the iliac artery deſcends to the pelvis and lower limbs, which of courſe grow larger, and the pelvis ſpreads wider and deeper: ſo that, by degrees, the womb and bladder are received into its cavity, without being any longer compreſſed by the inteſtines and peritonæum, when the abdominal muſcles preſs upon the lower parts of the abdomen. When now the increaſe is perfect, or next to it, then in general we find thoſe arteries of the uterus largeſt, which in the fœtus were leaſt, and eaſily injected with wax; and all things are changed in ſuch a manner, that the hemorrhoidal artery is now in place of the hypogaſtric (DCCCXXXVI.), when formerly the umbilical had been the trunk of that artery. More blood, therefore, at that time comes into the uterus, vagina, and clitoris, than formerly uſed to do.

DCCCLX. At the ſame time, when the growth of the body begins conſiderably to diminiſh, and the blood, finding eaſy admittance into the completed viſcera, is prepared in a greater quantity, the appetite being now very ſharp, in both ſexes, a plethora conſequently follows. In the male, it vents itſelf frequently by the noſe, from the exhaling veſſels of the pituitary membrane being dilated to ſo great a degree without a rupture, as to let the red blood diſtil through them (CCCCLVIII.); and now the ſemen firſt begins to be ſecreted, and the beard to grow. But in the female, the ſame plethora finds a more eaſy vent downward; being that way directed partly by the weight of the blood itſelf, to the uterine veſſels now much enlarged, of a ſoft fleecy fabric, ſeated in a looſe hollow part, with a great deal of cellular fabric interſperſed, which is very yielding and ſucculent, as we obſerve in the womb: for theſe cauſes, the veſſels being eaſily diſtendible, the blood finds a more eaſy paſſage through the very ſoft fleecy exhaling veſſels, which open into the cavity of the uterus, as being there leſs reſiſted than in its return by the veins, or in taking a courſe through any other part;

becauſe, in females, we obſerve the arteries of the head are both ſmaller in proportion, and of a more firm reſiſting texture. The return of the ſame is therefore more ſlow, both becauſe the flexures of the arteries, from the increaſed afflux of the blood, become more ſerpentine and fit for retarding the blood's motion, and likewiſe becauſe it now returns with difficulty through the veins. The blood is, therefore, firſt collected in the veſſels of the uterus, which at this time, by repeated diſſections, are obſerved to be ſwelled; next it is accumulated in the arteries of the loins and the aorta itſelf, which, urging on a new torrent of blood, augments the force, ſo far as to diſcharge the red blood into the ſerous veſſels, which at firſt tranſmit an increaſed quantity of warm mucus, afterward a reddiſh-coloured ſerum; and by ſuffering a greater diſtention, they at laſt emit the red blood itſelf. The ſame greater impulſe of blood, determined to the genital parts, drives out the hitherto latent hairs, increaſes the bulk of the clitoris, dilates the cavernous plexus of the vagina, and whets the female appetite to venery. Accordingly we find, that the quantity of the menſtrual flux, and the earlineſs of their appearance, are promoted by every thing that either increaſes the quantity or momentum of the blood with reſpect to the body in general, or which direct the courſe of the blood more particularly towards the uterus; ſuch as joy, luſt, bathing of the feet, a rich diet, warm air, and lively temperament of body. It is diminiſhed by thoſe things which leſſen plethora and the motion of the blood, as want, grief, cold air, ſloth, and antecedent diſeaſes.

DCCCLXI. When ſix or eight ounces of blood have been thus evacuated, the unloaded arteries now exert a greater force of elaſticity, and, like all arteries that have been overcharged with blood, contract themſelves by degrees to a leſs diameter, ſo as at length to give paſſage only to the former thin exhaling moiſture; but the plethora or quantity of blood, being again increaſed from the ſame cauſes, a like diſcharge will always more eaſily enſue through the veſſels of the uterus, after they have been once thus opened, than through any other part. Nor is there any occaſion to perplex ourſelves about the cauſe, why this periodical diſcharge is, for the moſt part, nearly regular or menſtrual; for this depends upon the proportion of the quantity and momentum of the blood daily collected, together with the reſiſtance of the uterus, which is to yield again gradually to the firſt courſe. Therefore this critical diſcharge of blood never waits for the interval of a month, but flows ſooner or later, according as the greater quantity of blood in plethoric women is determined, by luſt or other cauſes, towards the uterus. Finally, they ceaſe to flow altogether, when the uterus, like all the other ſolid parts of the body, has acquired ſo great a degree of hardneſs and reſiſtance, as cannot be overcome by the declining force of the heart and arteries, by which the blood and juices are driven on through all the veſſels. This increaſed hardneſs in the old uterus is ſo remarkable in the arteries and ovaries, that it eaſily diſcovers itſelf both to the knife and the injections of the anatomiſt. But, in general, brute animals have no menſes; becauſe, in them, the womb is in a manner rather membranous than fleſhy, with very firm or reſiſting veſſels, which, with the difference of their poſture, never permit a natural hemorrhagy from the noſtrils or other parts. They are wanting in men, becauſe in that ſex there is no ſpungy organ fit for retaining the blood; and likewiſe becauſe the arteries of the pelvis are both harder and leſs, in proportion, than the veins; and thus the impetus of the blood in the lower limbs is turned away, whoſe veſſels in men are larger, as thoſe of the pelvis are ſmaller.

DCCCLXII. It will, perhaps, be demanded, why the breaſts ſwell out at the ſame time with the approach of the menſes? We are to obſerve, that the breaſts have many particulars in their fabric, common to that of the uterus; as appears from the ſecretion of the milk in them after the birth of the fœtus, which increaſes or diminiſhes in proportion as the lochial flux is either increaſed or diminiſhed;

miniſhed; from the ſimilitude of the ſerous liquor, like whey, found in the uterus, ſo as to reſemble milk, in thoſe who do not ſuckle their children, being of a thin and white conſiſtence, appearing very evidently in brute animals; alſo from the turgeſcence or erection of the papillæ or nipples of the breaſt by friction, analogous to the erection of the clitoris. Therefore, the ſame cauſes which diſtend the veſſels of the uterus, likewiſe determine the blood more plentifully to the breaſts; the conſequence of which is an increaſed bulk and turgeſcence of the conglomerate glandules and cellular fabric which compoſe the breaſts.

CHAP. XXXI.

Of CONCEPTION.

DCCCLXIII. THIS is a very arduous inveſtigation, as we propoſe to diſcover the changes which take place in the inward parts of woman, when a new creature begins to germinate, who is, in proper time, to be expoſed to light. We ſhall relate, in the firſt place, therefore, thoſe things which experience ſhows to be true; and then add thoſe hypotheſes by which learned men have endeavoured to ſupply ſuch things as are not evident from the ſubject itſelf. How few things are aſcertained on this ſubject, and how difficultly they are aſcertained, I have learned by too much experience.

DCCCLXIV. That ſome light may be thrown on ſuch a dark ſubject, we ſhall begin with the moſt ſimple animals, and afterwards take notice of what nature has added in others whoſe fabric is more compounded. The ſmalleſt animals, then, which have very few or no limbs, the leaſt diſtinction of parts, the ſhorteſt life, the vital functions both few and very ſimilar to one another; theſe animals bring forth young ones like themſelves, with no diſtinction of ſexes, as all of them are fruitful, and none imparts fecundity to the reſt. Some of them exclude their young whom they have conceived in their body, through a certain cleft; from others, ſome limbs fall off, which are completed into animals of a kind ſimilar to thoſe from which they have fallen off. This kind of generation is extended very wide, and comprehends the greater part of animal life.

DCCCLXV. The next to theſe, which are a little more compounded, all bring forth their young; yet in ſuch a manner, that in their bodies is generated a certain particle peculiar to themſelves, diſſimilar to the whole animal, and contained in ſome involucra, within which lies the animalcule that is afterwards to become ſimilar to that within which it is produced; this is commonly called an *egg*. A great part of theſe animals is immoveable.

DCCCLXVI. The animals which follow are not indeed numerous, but have both eggs, and male ſemen beſides; ſo that both ſexes are joined in the ſame animal. But we call it *male ſemen*, becauſe it is neceſſary for ſprinkling the eggs in order to render them prolific, although it never grows alone into a new animal. In this claſs, therefore, a juice is prepared by its own proper organs, which is likewiſe poured on the eggs through organs proper to itſelf, but different from the former, in order to generation.

DCCCLXVII. Thoſe animals are much more numerous which have both a male juice and female eggs; yet ſuch as cannot fecundate themſelves, but require true coition. For two animals of this kind agree in the work of fecundation, in ſuch a manner, that each impregnates the other with its male organs, and again ſuffers itſelf to be impregnated in its female ones by the male parts of the other.

DCCCLXVIII. And now the nature of animals approaches nearer and nearer to that of the human race; of which, namely, ſome individuals of a ſimilar kind have only male organs, and the ſame males ſprinkle their ſeed on the female eggs of others. Very many cold ones ſprinkle their ſeed upon the eggs after they are poured out of the body of the mother. Warm animals inject their ſemen into the uterus of the female. But now, if eggs are generated within the body of the female, they are brought forth covered with ſhells or membranes; but if the female has a live fœtus in its uterus, it is born quite free of any involucrum: but the difference between theſe oviparous and viviparous animals is but ſmall; ſo that in the ſame claſs, and the ſame genus, ſome animals lay eggs, others produce live fœtuſes; and laſtly, the ſame animal ſometimes lays eggs, and ſometimes brings forth live young.

DCCCLXIX. From this review of animals it appears, that all animals are produced from others ſimilar to themſelves; many from a part of it ſimilar to the whole; others from an egg of a peculiar ſtructure; but that all theſe do not ſtand in need of male ſemen. Laſtly, the more moveable and lively animals only, whoſe bodies are of a more complicated ſtructure, are endowed with a double ſyſtem for generation; and the difference of ſexes ſeems to be added for the bond of ſocial life, and for the ſafety of a leſs numerous progeny.

DCCCLXX. For the certain effuſion of this male juice into the female organs, both ſexes are inflamed with the moſt vehement deſires; the male indeed has the moſt lively ones, becauſe the female is at all times ready to ſuffer the venereal congreſs; and thence it behoves the male to be animated with a deſire of venery, when he has plenty of good ſeed, and ſuch as is of a prolific nature. Therefore this is the greateſt cauſe of venereal deſire in him; but in females, of the brute kind eſpecially, ſome kind of inflammation in the vagina, which excites an intolerable itching.

DCCCLXXI. But nature has firſt added to the womb, both in women and in quadrupeds, a vagina or round membranous cavity, eaſily dilatable, which, as we have already ſeen (DCCCXLIII.), embraces and ſurrounds the projecting mouth of the uterus; from whence it deſcends obliquely forward under the bladder, and reſting upon the rectum with which it adheres, and laſtly opens under the urethra with an orifice a little contracted. This opening, in the fœtus and in virgins, has a remarkable wrinkled valve, formed as a production of the ſkin and cuticle, under the denomination of *hymen*, which ſerves to exclude the air or water; not perhaps without ſome kind of moral uſe, ſeeing this membrane, as far as I know, is given to women alone. It is circular, excepting a ſmall deficiency under the urethra, which yet is not always conſtant, but it turns broader towards the anus. This membrane being inſenſibly worn away by copulation, its lacerated portions at laſt diſappear. The caruncles, which are called *myrtiformes*, are partly the remains of the ſhattered hymen, and laſtly the valves of the mucous lacunæ hardened into a kind of fleſh.

DCCCLXXII. The fabric of the *vagina* is ſomewhat like that of the ſkin, compoſed of a firm, denſe, or callous cuticle, covering a thick, white, nervous ſkin, in which, more eſpecially at its end, appear fleſhy fibres. Its internal ſurface is, in a great meaſure, rough, beſet with many callous warts, which, though hard, are ſenſible: beſides which, there are thin plates, terminated with a protuberant inclined edge, pointing downward, ſo as to form two principal rows, ſpreading betwixt thoſe warts; and of theſe, the uppermoſt are extended under the urethra, where they are larger, as the lower are incumbent on the anus. From each of theſe to the other are continued, on both ſides, ſeveral rows of leſſer valve-like papillæ, variouſly inflected into arches, and which ſeem to be deſigned for increaſing the pleaſure, and facilitating the expanſion, when it is called for. It is furniſhed with a proper mucus of its own, ſeparated from particular ſinuſes in ſeveral parts, but more eſpecially in its poſterior and ſmoother ſide.

DCCCLXXIII. At the entrance of the vagina are prefixed two cautaneous productions or appendages, called *nymphæ*, continued from the cutis of the clitoris, and from the glans itſelf of that part; and theſe, being full of cellular ſubſtance in their middle, are of a turgeſcent or diſtenſible fabric, jagged and repleniſhed with ſebaceous glandules on each ſide, ſuch as are alſo found in the folds of the prepuce belonging to the clitoris. Their uſe is principally to direct the urine, which flows betwixt them both from the urethra, that in its deſcent it may be turned off from clinging to the body, in which office the nymphæ are drawn together with a ſort of erection. Theſe membranous productions deſcend from the cutaneous arch ſurrounding the *clitoris*, which is a part extremely ſenſible, and wonderfully influenced by titillation; for which it is made up, like the penis, of two cavernous bodies, ariſing in like manner from the ſame bones, and afterwards conjoining together in one body, but without including any urethra. It is furniſhed with blood-veſſels, nerves, and levator muſcles, and a ligament ſent down from the ſynchondroſis of the os pubis, like thoſe in men, like unto which the clitoris grows turgid and erect in the time of coition, but leſs in thoſe who are very modeſt; but from friction, the clitoris always ſwells up and is erected.

DCCCLXXIV. The muſcle, termed *oſtii vaginæ conſtrictor*, ariſing on each ſide from the ſphincter of the anus, and increaſed by the acceſſion of a branch from the os iſchium, covers the vaſcular plexus, from whence it proceeds outward in the direction of the labia externa, and is inſerted into the crura clitoridis; thus it ſeems to compreſs the lateral venal plexuſes of the vagina, whence it every way conduces to retard the return of the venal blood. The tranſverſe muſcle of the urethra, and the bundle from the ſphincter inſerted into it, have the ſame ſituation as in men.

DCCCLXXV. When a woman is invited either by moral love, or a luſtful deſire of pleaſure, and admits the embraces of the male, the penis, entering the vagina, rubs againſt its ſides, until the male ſeed breaks out and is poured into the uterus. In like manner the attrition of the very ſenſible and tender parts, which lie within the vagina, excites a convulſive conſtriction, as we obſerved before of the male (DCCCXL.) By theſe means the return of the venous blood being ſuppreſſed, the clitoris grows turgid and erect, more eſpecially in luſtful women; the nymphæ ſwell on each ſide, as well as the venal plexus, which almoſt ſurrounds the whole vagina, ſo as to raiſe the pleaſure to the higheſt pitch: in conſequence of which there is expelled, by the muſcular force of the conſtrictor (DCCCLXXIV.), but not perpetually, nor in all women, a quantity of lubricating mucous liquor, of various kinds. The principal fountains of this are ſeated at the firſt beginning or opening of the urethra, where there are large mucous ſinuſes placed in the protuberant margin of this uriniferous canal. Moreover, there are two or three large mucous ſinuſes, which open themſelves into the cavity of the vagina itſelf, at the ſides of the urethra, in the bottom of the ſinuſes which are formed by the membranous valves ſulcated upward. Laſtly, at the ſides of the vagina, betwixt the bottoms of the nymphæ and the hymen, there is one opening, on each ſide, from a very long duct; which, deſcending towards the anus, receives its mucus from a number of very ſmall follicles.

DCCCLXXVI. But the ſame action which, by increaſing the pleaſure to the higheſt degree, cauſes a greater conflux of blood to the whole genital ſyſtem of the female (DLXIII.), occaſions a much more important alteration in the interior parts. For the hot male ſemen, penetrating the tender and ſenſible cavity of the uterus, which is itſelf now turgid with influent blood, does there excite, at the ſame time, a turgeſcence and diſtention of the lateral tubes, which are very full of veſſels, creeping betwixt their two coats, and now ſtiff with the great quantity of blood they contain; and theſe tubes, thus copiouſly filled and florid with the red blood, become erect, and aſcend, ſo as to apply the ruffle or fingered opening of the tube to the ovary. In the truth of all theſe particular changes, we are confirmed by diſſections of gravid or pregnant women, under various circumſtances; alſo from the comparative anatomy of brute animals, and from the appearances of the parts when diſeaſed.

DCCCLXXVII. But, a in female of ripe years, the ovary is extremely turgid, with a lymphatic fluid, which will harden like the white of an egg, and with which little bladders are diſtended. In a prolific copulation, ſome one of the more ripe veſicles is burſt, a cleft manifeſtly appears, and at length pours out a clot of blood. Within this veſicle, after copulation, a kind of fleſh grows up, at firſt flocculent, than granulated, and like a conglomerate gland, conſiſting of many kernels joined together by a cellular ſubſtance; which fleſh by degrees becoming larger and harder fills the whole cavity of the veſicle, and is hardened into the nature of a ſcirrhus, in which, for a long time, remains a cleft, or a veſtige of one. This is the *corpus luteum*[182], common to all warm quadrupeds, in which ſome late anatomiſts have found a ſort of juice before copulation; which, however, experience does not admit, ſeeing there is no corpus luteum at that age. Nor is the veſicle, which is the human ovum, contained in a body like a cup.

DCCCLXXVIII. The extremity of the tube, therefore, ſurrounding and compreſſing the ovarium in a prolific congreſs, is thought to preſs out and ſwallow a mature ovum, from a fiſſure in the outer membrane, from whence it is continued down by the periſtaltic motion of the tube, to the uterus itſelf; which periſtaltic motion begins from the firſt point of contact with the ovum, and urges the ovum domnward ſucceſſively to the opening into the fundus uteri, which is very manifeſt in brute animals. The truth of this appears from the conſtant obſervation of a ſcar or fiſſure in the ovarium, which is produced there after conception;

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[182] The nnmber of corpora lutea for the moſt part correſponds with that of the fœtuſes: you will eaſily ſee a pretty mechaniſm in ſwine; whoſe ovaria are the likeſt, of all quadrupeds, to true ovaria. In any corpus luteum we diſtinguiſh as if a double ſubſtance, like a cortical and medullary part. Hunter has given elegant repreſentations of them; and we have very good deſcriptions of them from Bertrand and Huber.

from a fœtus being certainly found in quadrupeds, both in the ovarium of the female, and in the tube; from the analogy of birds, in which the deſcent of the ovum from the ovarium is very manifeſt. Yet we muſt acknowledge, that a true ovum was never found in quadrupeds, unleſs after a long time. It is probable, that at the time of conception, the true ovum is almoſt fluid, very ſoft and pellucid, and cannot be diſtinguiſhed from the mucus with which the tube is filled; likewiſe, that it is very ſmall, on account of the narrowneſs of the tube. The veſicle itſelf which was in the ovary remains in it fixed, and becomes the covering of the corpus luteum. But the accounts of ova ſaid to have fallen from women during the firſt days are not certain, and are contradicted by the ſmallneſs of the fœtus obſerved many days after conception; by the ſhape in which it is firſt obſerved, which is always oblong, and in brutes even cylindrical; and likewiſe by the ſmallneſs of the tube.

DCCCLXXIX. Theſe things are performed, not without pleaſure to the future mother, nor without a peculiar ſort of ſenſation of the internal parts of the tube, threatening to induce a ſwoon. Neither is the place of conception in the uterus, to which certain experience ſhews that the male ſemen comes. For the power of the male ſemen fecundates the ovum in the ovaria themſelves, as we ſee in the caſe of fœtuſes found in the ovaries and tubes; from the analogy of birds, in which by copulation one egg indeed falls into the uterus, but very many are fecundated at once in the ovaria. Nor is the ſmall quantity of the male ſemen, or its ſluggiſh nature, any objection to this, which by eminent anatomiſts has been thought to render it leſs fit for performing ſuch a journey. For it is certain that the male ſemen fills the tubes themſelves at the firſt impregnation, both in women and brute animals.

DCCCLXXX. The uterus indeed, in animals certainly, and in women probably, is cloſed, leſt the very ſmall ovum, together with the hope of the new progeny, ſhould periſh. At that time the new mother ſuffers many diſagreeable affections; which probably ariſe from the ſubputrid and ſubalkaline male ſemen reſorbed into the blood. A nauſea is occaſioned by conception, almoſt in the ſame manner as by ſwallowing a bit of a rotten egg. Fleſh is at this ſame time chiefly nauſeated; a vomiting alſo occurs; ſome puſtules break out, and the teeth ach. The moſt of theſe complaints I reckon to be owing to the ſwelling of the uterus, and the retention of the menſes.

DCCCLXXXI. Theſe changes, hitherto, which are proved at leaſt by the teſtimony of our ſenſes, may be either confirmed or corrected. Thoſe which follow are more conjectural; and the more difficult on account of the paucity of experiments, and their diſagreement with one another. And in the firſt place, it is a difficult queſtion, From whence proceed the firſt ſtamina of the new animal? Whether are they from both parents, and mixed into one animal by a conjunction of ſeminal matter coming from the whole body; as indeed there is a reſemblance of the fœtus to both parents in animals, but eſpecially in plants, as confirmed by very many experiments: the ſame thing alſo ſeems confirmed by the faults of parents being conveyed to their children. But no ſeed has ever certainly been obſerved in females; and innumerable examples ſhow, that the ſpecies of animals may be propagated without any mixture of ſeeds. Laſtly, the reſemblance of the young animal to its father ſeems only to ſhow, that in the male ſeed there is ſome power, which alone can form the ſoft matter of the embryo in its leaſt ſtate; juſt in the ſame manner as that power adds length to the pelvis in certain bodies, dilates the larynx, and cauſes the horns appear.

DCCCLXXXII. To the father ſome have attributed every thing; chiefly ſince the ſeminal worms, now ſo well known, were firſt obſerved in the male ſeed by the help of the microſcope, which are obſerved with truth to agree in figure with the firſt embryos of all animals. But in theſe animals there is a proportion wanting betwixt their number and that of the fœtuſes; they are alſo not to be conſtantly obſerved through all the different tribes of animals; they have too great a reſemblance to thoſe animalcules that are every where ſpontaneouſly produced in other juices, which yet are always tenacious of their own genus, and are never found to grow in the moſt diſſimilar kinds of animals that have limbs.

DCCCLXXXIII. Again, other anatomiſts, not leſs celebrated or leſs worthy of credit, have taught that the fœtus exiſted in the mother and maternal ovary; which the male ſemen excites into a more active life, and likewiſe forms it variouſly, ſo as to ſhow it juſt brought into life, and make its preſence manifeſt. That yolks are alſo manifeſtly found in the female ovaries, even altho' they have not been impregnated with any male ſemen. But a yolk is known to be an appendix to the inteſtine of fowls; and to have its arteries from the meſenteric artery, and the covering of the yolk to be continued with the nervous membrane of the inteſtine, which is continuous with the ſkin of the animal. That along with the yolk, therefore, the fœtus ſeems to be preſent in the mother hen, of whom the yolk is a part, and which gives veſſels to the yolk. Laſtly, that the analogy of nature ſhows that many animals generate eggs without any connection with a male of the ſame ſpecies, but that a male animal never becomes prolific without a female. That the progreſſions are continued from a female quadruped to an oviparous animal, and from that to one which is not oviparous; but that the new animal proceeds from a part of the old one. Certainly, therefore, the males muſt give ſome addition to that ſex which produces the fœtus from its own body; which addition is neceſſary in ſome tribes of animals, but in others, even the moſt fruitful, may be wanted. And that it is not poſſible with any kind of truth to admit of any inſertion, by which the open navel of the male animal, when conceived, ſhould adhere to the veſſels of the female. For this navel would be by far too ſmall at the time when the yolk is of a conſiderable bigneſs; neither could the very ſmall umbilical arteries be applied

plied to the very large yolk with any hope of a continuance of the circulation.

DCCCLXXXIV. Thus much concerning the materials: but we are again at a loſs concerning the formation, by what means the rude and ſhapeleſs maſs of the firſt embryo is faſhioned into the beautiful ſhape of the human body. We readily reject ſuch cauſes as a fortuitious concourſe of atoms, the blind attractions between the particles of the nutritious juices, and the ſtrength of ferments, inconſcious of the reaſons why they operate; the ſoul is certainly an architect unequal to the taſk of producing ſuch a beautiful fabric; as for internal models, of which I never could conceive one clear idea in my mind, we ſhall refer them to thoſe hypotheſes which the deſire of explaining thoſe things, of which we are unwillingly ignorant, has given riſe to.

DCCCLXXXV. To me, indeed, experience ſeems to agree with thoſe things which the mind foreſees will follow from their own cauſes. Namely, that this moſt beautiful frame of animals is ſo various, and ſo exquiſitely fitted for its proper and diſtinct functions of every kind, and the offices and manner of life for which the animal is deſigned; that it is calculated according to laws more perfect than any human geometry; that the ends have been foreſeen in the eye, in the ear, and the hand, ſo that to theſe ends every thing is moſt evidently accommodated: it appears, therefore, certain to me, that no cauſe can be aſſigned for it below the infinite wiſdom of the Creator himſelf. Again, the more frequently, or the more minutely, we obſerve the long ſeries of increaſe through which the ſhapeleſs embryo is brought to the perfection neceſſary for animal life, ſo much the more certainly does it appear, that thoſe things which are obſerved in the more perfect fœtus have been preſent in the tender embryo, although the ſituation, figure and compoſition ſeem at firſt to have been exceedingly different from what they ſhow themſelves to be at laſt; for an unwearied and laborious patience has diſcovered the intermediate degrees by which the ſituation, figure, and ſymmetry, are inſenbly reformed. Even the tranſparency of the primary fœtus alone conceals many things which the colour added a little after does not generate, but renders conſpicuous to the eye. And it ſufficiently appears that thoſe parts which eminent anatomiſts have ſuppoſed in aftertimes to be generated, and to be added to the primeval ones, have been all cotemporary with the primeval parts, only ſmall, ſoft, and colourleſs.

DCCCLXXXVI. It is highly probable, that for a long time the latent embryo neither increaſes nor is agitated, except by a very gentle motion of the humours, which we may ſuppoſe to librate from the heart into the neighbouring arteries, and from theſe into the heart of the fœtus. But we may alſo ſuppoſe, that the ſtimulus of the male ſemen excites the heart of the fœtus to greater contractions, ſo that it inſenſibly evolves the complicated veſſels of the reſt of the body by the impulſe of the humours, and propagates the vital motion through all the canals of the little body of the animal; that it is more quick in ſome parts, and more ſlow in others; and that from thence it happens that ſome parts of the body of the animal ſeem to be produced very early, and others to ſupervene afterwards; and laſtly, that ſome do not ſhow themſelves until a long time after birth, as the veſicles of the ovaries, the veſſels of the male teſticles, the teeth, hairs of the beard, and horns of brute animals. In all animals, heat aſſiſts this evolution; in the more ſimple ones, whoſe veſſels are few, and leſs complicated in their various origins, it is the ſole inſtrument of bringing it to perfection[183].

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[183] How great difficulties, diſcordant opinions, and innumerable conjectures, prevail in the doctrine concerning animal generation, no perſon can be ignorant, who, after the immortal work of Haller, in which theſaurus we have every thing mentioned from the beginning of ſcience down to our times concerning the theory of generation, conſults the works of the lateſt authors of reputation, Needham, Buffon, Bonnetus, Wolf, which, we have good reaſon to apprehend,

DCCCLXXXVII. Of the objections which are uſually brought, ſome are not true; ſuch as the ſuppoſition of an excreſcence of a different ſtructure from the reſt of the body; others ſeem to belong to cauſes depending on ſome accident, ſuch as moſt kinds of monſters; ſome to the increaſe of ſome particular parts, occaſioned by the powers of the male ſeed; ſome to the cellular texture variouſly relaxed, as it ſeems to increaſe in the parts newly produced, or to be occaſioned by indurated juices. Although it is not eaſy to explain every thing mechanically, yet we ought to remember, that if indeed the new animal is truly, and ſhown by experience to be, preſent in the egg, thoſe difficulties which are moved cannot overturn ſuch things as have been truly demonſtrated, although perhaps ſome things may remain, to which, in ſo great an infancy of human knowledge, we cannot yet give a full anſwer.

DCCCLXXXVIII. When the human ovum is brought down into the uterus, we become more ſenſible of its change of ſhape after the interval of a few days. The ovum itſelf ſends out every where ſoft branchy flocculi from

prehend, are not free of every difficulty, although they have been partly confirmed by the labours of prior authors, and partly increaſed by new reflections from Fabricius, Harvey, Graaf, Malphigius, Valiſner, &c. Nature ſhows great regularity in the production of animals and vegetables, though all are not generated in one and the ſame way: all plants do not originate from ſeeds, nor animals from eggs; but in any kingdom of natural bodies, ſome are produced in the moſt ſimple way, without the neceſſity of both ſexes, and from a particle, reſembling a whole individual, ariſes a new individual: but others are produced by means of proper organs, and by new generation. The excellent obſervations of Necker, Munchus, Koelrute, Helwig, Mont, Cort, about muſhrooms, moſſes, and other cryptogamic plants ſo called; Ellis's, Butner's, Bochadſch's, Pallas's, and Diequemare's obſervations about corals and other ſea bodies; De Geer, Bonnetus, Schroetes, Goetz, and Sinebier, about ſeveral animals; Spallanzani, Muller, Sauſſure, Terechoſsky, and our own experiments, upon animalcula; Trembley, Roeſel, Reaumur, Schaffer, about polypi: and likewiſe Spallanzani, Shaeffer, Watel, and Murray, upon ſhells and ſnails; and Spallanzani's, and my own trials, upon lizards; all theſe I ſay, have convinced me, that our whole knowledge of generation conſiſts merely of phenomena, upon which it has as yet been impoſſible to raiſe a true and infallible ſyſtem.

from the ſuperficies of its membrane hitherto ſmooth, which adhere to and inoſculate with the exhaling and reſorbing flocculi of the uterus (DCCCXLIII.) This adheſion happens every where in the uterus; but chiefly in that thick part which is interpoſed between the tubes, and is called the *fundus uteri*. Thus the thin ſerous humour of the uterus, proceeding from its arterial villi, is received into the ſlender venous veſſels of the ovum, and nouriſhes it together with the fœtus. But before this adheſion, it is either nouriſhed by the matter it already contains, or elſe by ſuch juices as it abſorbs from the ſurrounding humours, if indeed there is any time when it does not adhere.

DCCCLXXXIX. At this time, in the ovum, there is a great proportion of a limpid watery liquor, which, like the white of an egg, hardens by the heat of fire, or a mixture with alcohol; and now the fœtus, for a long time inviſible, as I have never obſerved it before the 17th day, makes its appearance at firſt a ſhapeleſs maſs, conſiſting of mere mucus, and as yet ſeemingly of a cylindrical ſhape. When ſome diſtinction of parts is next to be ſeen, it has a very great head, a ſmall ſlender body, no limbs, fixed by a very broad flat navel to the obtuſe end of the ovum.

DCCCXC. From hence forward the fœtus continually increaſes as well as the ovum, but in an unequal proportion: for while the arterial ſerum is conveyed by more open paſſages into the ſmaller veſſels of the ovum, the fœtus itſelf grows the faſteſt; becauſe now the greateſt part of its nouriſhment ſeems to paſs through the very large umbilical vein. At the ſame time the ovum itſelf alſo grows, but leſs in proportion; and the waters, which it includes, gradually diminiſh from their firſt proportion, in reſpect of the bulk of the fœtus. The fleecy productions of the veſſels from the ovum are gradually ſpread over with a continued membrane, and only thoſe which ſprout out from the obtuſe end of the ovum take root, or increaſe ſo as to form a round circumſcribed placenta or cake.

DCCCXCI. Such is the appearance of the ovum, as we have here deſcribed it, commonly in the ſecond month; from which time it changes only by increaſing in bulk. That part of the ovum next the fundus uteri is commonly uppermoſt, making about a third of its whole ſurface, in form of a flat round diſh or plate; ſucculent, fibrous, full of protuberances, but throughout perfectly vaſcular; changing into other tubercles of the ſame kind, for the moſt part accurately, and often inſeparably, connected with the uppermoſt part of the uterus, remarkable for its large veſſels, of a thin cellular texture, collecting the veſſels every where, but chiefly in the circumference of the greateſt circle, as well the exhaling arteries anſwering to ſuch as come from the uterus into the veins of the placenta, as the arteries of the placenta opening into the large veins of the uterus. There, in the common ſurface of the uterus and placenta, a communication is made, by which the uterus ſends to the fœtus, firſt that white ſerous liquor not unlike milk, and laſtly, as it ſeems, red blood itſelf. This communication of the humours ſeems to be demonſtrated by the ſuppreſſion of the menſes in women with child, whoſe blood muſt be turned into another channel; from the loſs of blood which follows from a ſeparation of the placenta in a miſcarriage; and from the blood of the fœtus being exhauſted from an hemorrhagy in the mother; from hemorrhagies that enſue from the navel-ſtring, ſo as to kill the mother when the placenta has been left adhering to the uterus; and, laſtly, from the paſſage of water, quickſilver, tallow, or wax, injected from the uterine arteries of the mother into the veſſels of the placenta, as is confirmed by the moſt faithful obſervations. But that it is blood which is ſent into the fœtus, is evinced by the magnitude of the ſinuſes of the uterus and placenta; the diameter of the ſerpentine arteries of the uterus; the hemorrhagy that follows, even when the placenta is very ſlightly hurt; but eſpecially by the motion of the blood, which, in a fœtus deſtitute of a heart, could only be given to the humours of the fœtus by the blood of the mother[184].

DCCCXCII.

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[184] The manner in which the fœtus is nouriſhed after conception, labours under a like difficulty with the origin of conception itſelf. Of the two moſt noted conjectures which uſually explain the communication of the uterus with the placenta, reſorption, or the immediate anaſtomoſis of the blood-veſſels, the laſt has always had the moſt partiſans. I am ſorry that various arguments, ſufficiently weighty, prevent me from ſo eaſily embracing the ſame ſide; which arguments my celebrated pupils, Balthaſer and Moeller, have already mentioned, and which ſhall now be partly delivered by myſelf. They may be conveniently divided into two claſſes; the firſt contains the doubts of anaſtomoſis; the laſt, the arguments tending to prove it. In the firſt claſs it is denied,

1. Becauſe the young of birds, removed at a great diſtance from their mother, ſo that they cannot get any blood from her, prepare true blood from their own nouriſhment, the yolk and white.

2. Anaſtomoſis between veſſels of ſo great magnitude and importance, the abſtraction of which ſo large a hemorrhagy frequently follows, ought not to be formed and ſupported by veſſels ſo very ſmall and imperceptible to the naked eye, but by larger ones; the number of which, however, in the natural abſtraction of the ſecundines, we find neither in the uterus nor placenta to be great.

3. As often as I have taken the egg from the uterus of animals which have died at various periods of pregnancy, I always found in the uterus a liquor reſembling milk, rarely blood.

4. By the moſt ſucceſsful injections, made with all due care, once into the uterus of a pregnant woman who died in the ſeventh month of geſtation of a wound, ſeveral times into the wombs of mares, cows, goats, rabbits, dogs, and cats, &c. preparations of which I poſſeſs, I never could convey the ſmalleſt quantity of the moſt ſubtile liquor into the uterus from the veſſels of the cord, nor from the veſſels of the uterus into the placenta: the liquor entered only the cellular texture of the fungous chorion, and filled it with irregular particles.

5. I have ſometimes filled the recent ſecundines of women, and ſeveral brutes, that have come away ſpontaneouſly immediately after birth; but I never ſaw the mercury ruſhing forward, as we ſhould have obſerved in the rupture of anaſtomoſing veſſels, which nevertheleſs penetrates the moſt ſubtile veſſels.

6. I have met with a few dogs juſt before birth killed by cutting through the carotids; which being almoſt half alive, I have filled through the uterine veſſels with a very ſubtile liquor. The preparations which I poſſeſs are proofs of the moſt happy and ſucceſsful injection. However, I have done nothing more in theſe than to puſh the fluid and coloured matter into the cells of the fungous chorion; but there are not the ſmalleſt traces of its entering the veſſels of

DCCCXCII. The remaining part of the ovum, and likewiſe the ſurface of the placenta, are covered by an external

of the placenta. As to the other ſide of the queſtion, the arguments there are not of leſs weight: for,

1. The ſuppreſſion of the menſes in pregnancy cannot ſo much prove it, ſince (*a*) ſeveral animals have no menſes: (*b*) they are not ſuppreſſed in all women; (*c*) the maſs of menſtrual blood ſuppreſſed after conception, amounting to twelve, ſixteen, or even twenty ounces, can in no ways be expended upon the ſmall maſs of embryo of the firſt or ſecond month, which, together with the ſecundines, weighs ſcarce an ounce.

2. Thoſe great and dangerous hemorrhagies which happen after the abſtraction of the human placenta, excite no ſmall ſuſpicion of an immediate anaſtomoſis. But (*a*) the flow of blood does not happen in all with the ſame force; but is ſometimes ſeveral pounds, ſometimes a few ounces and drachms: (*b*) and the ſame flux is the more gentle the more carefully the abſtraction has been performed, and *vice verſa;* and in very profuſe fluxes the uterus is, for the moſt part, more or leſs injured. (*c*) I have ſeen abortions of two or three months attended with a very ſmall profuſion; and I now remember five in which ſcarce an ounce was loſt. (*d*) In the birth of brutes, ſo large effuſions never happen, or do not laſt ſo long.

3. It would truly be a weighty argument, which would eaſily determine me to embrace the doctrine of anaſtomoſis, if I could reconcile it with my own obſervations, that the fœtus is deprived of a great part of its blood if the mother has died of an hemorrhagy. But I have ſeen (*a*) a human fœtus whoſe mother had died in the ſeventh month of geſtation of a very bloody wound, and had ſuffered a great effuſion, which had loſt no blood out of the heart nor larger veſſels; nay, not even in the placenta itſelf did the ſtate of the blood-veſſels exhibit any mark of hemorrhagy. (*b*) Next, I have killed pregnant dogs and cats, juſt upon the time of birth, by cutting the carotids; I have examined the uterus of cows and mares, killed by means of a very large wound of the heart, without finding in any of them either the ova or fœtus ſhowing the leaſt defect of blood.

4. That mothers may ſuffer fatal hemorrhagies from cutting and not tying the cord, neither my own obſervations, nor thoſe of Roederer, will allow; and no perſon at preſent directs midwives to begin the tying of the cord towards the placenta.

5. The venous ſinuſes, ſo called, in the uterus, except the cellular ſubſtance of the fungous chorion, ſeem to afford no proof. I have obſerved ſuch ſinuſes, ſo called, in the uterus, if a very great part of the ſpongy chorion has cohered to the uterus. I have perceived them on the placenta, if it had adhered to it. The blood detained here does not abſolutely demonſtrate the continuation of veſſels: it only ſhows, that a certain ſtore is prepared, from which the abſorbent

external villous and fleecy membrane, full of pores and ſmall veſſels, of a reticular fabric, eaſily lacerable, ſo as to reſemble a fine placenta, and is called the *chorion*. But even this is connected to the flocculent ſurface of the uterus, which is very like to itſelf, but ſofter, by veſſels ſmaller than thoſe of the placenta, but manifeſtly inoſculated from the chorion into the veſſels of the uterus.

DCCCXCIII. Under the chorion lies a continuous, white, opaque, and firm membrane, not vaſcular, which does not cover the part of the placenta turned towards the uterus, but is concave, and turned to the fœtus. It coheres by a cellular texture both to the chorion and amnios. The moſt ſimple name we can give it, is the *middle* membrane[185].

DCCCXCIV. The innermoſt coat of the fœtus, which is called *amnios*, is a watery pellucid membrane, very rarely ſpread with any conſpicuous veſſels, which yet I have obſerved in an human ſubject; extremely ſmooth, and in all parts alike; alſo extended under the placenta with the former, the ſurface of which is every way in contact with the waters. If there are more fœtuſes than one, either in man or beaſt, each of them has their proper amnios.

DCCCXCV.

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bent veſſels of the placenta may receive their nouriſhing matter, which contains a mixture of the blood itſelf tranſmitted through the increaſing veins, whoſe reſiduum is reabſorbed by the veins of the uterus, and at length mixed with the blood. Does not the like happen in other ſpongy parts?

6. As to examples of fœtuſes wanting the heart, whoſe circulation therefore ſhould have depended upon the mother alone, although I am not ſo certain of the truth of them, I could oppoſe as many other obſervations of a ſimilar monſtrous mechaniſm in birds.

[185] There are three real tunics of the human ovum, any of which may be ſeparated into new lamella. The outermoſt, which ſhould be called the fungous or ſpongy chorion, is almoſt the ſame ſubſtance with the acetabula in the ſecundines of brutes, that part, to wit, proper partly to the uterus, partly to the placenta, which has been excellently deſcribed by Cooper and Sandifort; but moſt elegantly delineated by the famous Dr Hunter. The middle one may be called *læve chorium*, and the innermoſt one is known by the name of *amnium*.

DCCCXCV. The nouriſhment of the fœtus, from the beginning to the end of the conception, is without doubt conveyed to it through the *umbilical vein.* This gathers its roots from the exhaling veſſels of the uterus (DCCCLIV.), and it has manifeſt communications by ſome roots with the umbilical artery, from whence it in part riſes, and, meeting together in a large trunk, is twiſted in a circular manner through a number of folds to a ſufficient length, that may allow of a free motion; and in this courſe it is ſurrounded with a cellular ſubſtance full of mucus, diſtinguiſhed by three partitions, and the membrane which is continued to the amnios, but known by the name of the *umbilical rope;* and after forming ſome protuberances, it enters through the navel, in an arch made by a parting of the ſkin and abdominal muſcles, and goes on through a proper ſinus of the liver (DCXCII.), into which the ſmaller portion of the blood that it conveys is poured through the ſlender ductus venoſus into the vena cava ſeated in the poſterior foſſa of the liver: but the greater part of its blood goes through the large hepatic branches, which conſtantly ariſe from its ſulcus, and remain even in the adult (DCXCV.); but it goes thence to the heart by the continuous branches of the vena cava (DCXCVII.) The ſinus or left branch of the vena portarum itſelf is a part of the umbilical vein, and its branches bring the blood from the placenta to the cava, while the right branch alone carries the meſenteric and ſplenic blood through the liver.

DCCCXCVI. But this is not all the uſe of the placenta; for the fœtus ſends great part of its blood again into the ſubſtance thereof, by two large *umbilical arteries*, which are continued on in the direction of the aorta; and after giving ſome ſlender twigs to the femorals, with ſtill ſmaller arteries into the pelvis, they aſcend reflected back with the bladder on each ſide of it, ſurrounded with the cellular plate of the peritonæum, with ſome fibres ſpreading to them from the bladder and urachus, in which manner they proceed on the outſide of the peritonæum into the cord at the navel, in which paſſing alternately in a ſtraight and contorted courſe, they form various twiſtings or windings, ſomewhat ſharper than thoſe of the vein which they play around; in which manner they at laſt arrive at the placenta, whoſe ſubſtance is entirely made up of their branches, in conjunction with thoſe of their correſponding veins, and a ſlippery cellular ſubſtance following both veſſels; ſo that the kernels themſelves, that are conſpicuous in the placenta, are convolutions of thoſe veſſels. By theſe branches the blood ſeems to paſs out through the minute arteries of the placenta into the bibulous veins of the maternal uterus, that after undergoing the action of the lungs by the mother's reſpiration, it may return again in an improved ſtate to the fœtus: for what other reaſon can be aſſigned for ſuch large arteries, which carry off above a third part of the blood of the fœtus?

DCCCXCVII. But it will perhaps be demanded, Whether the fœtus is not nouriſhed by the mouth likewiſe? Whether it does not drink of the lymphatic liquor contained in the cavity of the amnios, which is coagulable, unleſs putrefied, and in the middle of which the fœtus ſwims, and whoſe origin is not ſufficiently known? Whether this opinion is not in ſome meaſure confirmed by the open mouth of the fœtus, and the analogy of chickens, which are under a neceſſity of being nouriſhed from the contents of the egg only? to which add the abſence of a navel-ſtring in ſome fœtuſes; the quantity of meconium filling the large, and part of the ſmall, inteſtines; the ſimilitude of the liquor found in the cavity of the ſtomach to that which fills the amnios; the proportionable decreaſe of the liquor amnii, as the fœtus enlarges; the glutinous threads which are found continued from the amnios, through the mouth and gula, into the ſtomach of the fœtus; the true feces found in the ſtomach of the fœtus of quadrupeds; the open mouth of the fœtus, which we have certainly obſerved; the gaping of a chicken ſwimming in this liquor, and its attempts as it were to drink it up? Again, what are the fountains, or ſprings from whence this lymph of the amnios flows? whether it tranſudes thro' the inviſible veſſels of the amnios, or through certain pores from the ſucculent chorion, which is itſelf ſupplied from the uterus? It muſt be confeſſed, that theſe inquiries labour under obſcurities on all ſides; notwithſtanding which, there ſeems more probability for them than otherwiſe, ſince the liquor is of a nutritious kind, at leaſt in the firſt beginnings of the fœtus, and derived from the uterus.

DCCCXCVIII. All the excremental feces, which are collected in the fœtus during the whole time of its reſidence in the womb, amount to no great quantity, as they are the remains of ſuch thin nutritious juices, percolated through the ſmalleſt veſſels of the uterus. I frequently obſerve, that the bladder is almoſt empty in the fœtus. However, there is generally ſome quantity of urine, collected in a very long conical bladder. But in the cavity of the inteſtines, there is collected together a large quantity of a dark green pulp, which may poſſibly be the remains of the exhaling juices[186], like the feculent remains, which are ſometimes left in the other cavities of the body that are filled with exhaling juices, and ſuch as I have ſometimes obſerved even in the vaginal coat of the teſticle.

DCCCXCIX. It may then be demanded, whether there is any allantois? ſince it is certain that there paſſes out from the top of the bladder a duct called the *urachus*, which is a tender canal, firſt broad, covered by the longitudinal fibres of the bladder as with a capſule; and afterwards, when thoſe fibres have departed from each other, it is continued thin, but hollow, for a conſiderable way over the umbilical cord, yet ſo that it vaniſhes in the cord itſelf. Whether this, although it be not yet evident in the human ſpecies, is not confirmed by the analogy of brute animals, which have both

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[186] The greateſt part of the meconium unqueſtionably ariſes from the bile, which is very plentifully ſecreted by the fœtus, the magnitude of the liver being ſo great.

both an urachus and an allantois? But as for any proper receptacle continuous with the hollow urachus, it either has not yet been obſerved with ſufficient certainty, or elſe the experiment has not been often enough repeated, to render the opinion general in the human ſpecies; and thoſe eminent anatomiſts who have obſerved a fourth kind of veſſel to be continued along the umbilical rope into its proper veſicle, will not allow that veſſel to be called the urachus, and very lately have referred it to the omphalo-meſenteric genus[187]; and in the human fœtus, the urine is ſeparated in a very ſmall quantity: but it perhaps may be no improbable conjecture, that ſome portion of the urine is conveyed to a certain extent into the funiculus umbilicalis, and there is transfuſed into the ſpungy cellular fabric that ſurrounds it; and therefore, that, of all animals, man has the longeſt umbilical cord, becauſe he alone has no allantois. But then this can take up but a ſmall ſpace, terminating in the funis, and hardly ever ſeems to reach as far as the placenta. Sometimes, even in an adult perſon, this open duct has brought the urine to the navel.

DCCCC. In the mean time, the fœtus continues to advance in growth; the limbs by degrees ſprout from the trunk, under the form of tubercles; and the other outworks of the human fabricature are by degrees beautifully finiſhed, and added to the reſt; in a manner not here to be at large deſcribed, as indeed it has not been as yet by anatomiſts in general; of which, however, we muſt premiſe ſome compendium.

DCCCCI. The embryo which we firſt obſerved in the uterus of the mother was a gelatinous matter, having ſcarce any proper ſhape, and of which one part could not be diſtinguiſhed from another. There was, however, in that gluten a heart, which was the cauſe of life and motion; there were veſſels which generated the humour of the amnios; there were therefore veſſels of the umbilicus and yolk, the little trunks of which, being received from the fœtus, are at that time very large, ſeeing they have lately begun to be obſerved. There was both a head and ſpinal column, both parts very large, and larger in proportion to the reſt than ever. There were likewiſe, without doubt, all the reſt of the viſcera, but pellucid and of a mucous nature; for which reaſon, they may be obſerved ſome days ſooner than can be hoped for from nature alone, if you render them opaque.

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[187] Since I firſt made a drawing in my anatomical deſcriptions of the embryo, after Albinus and Bœhmer, concerning the bladder reſembling the allantois, which Hunter and Sandifort have confirmed by an elegant figure, I have twice had an opportunity of ſeeing the ſame with a ſimilar filament. I filled another fœtus with wax; and that filament which might impoſe upon us for the urachus was likewiſe filled: the artery certainly ran from the veſſels of the omentum to the cord, and was diſtributed in very ſmall branches through the cellular texture of the rope and upon the bladder.

DCCCCII. But in the whole fœtus, an immenſe quantity of water is mixed together with a very little earth, as the very cellular texture ſurrounds it in a ſtate between fluid and ſolid; ſeeing large drops of water are interpoſed betwixt the remote elements of the ſolid parts.

DCCCCIII. In birds there is added to this the vivifying gluten or white of the egg, which is of the nature of lymph; and the yolk, which is of an oily nature: in man, ſomething of a milky nature, not altogether unlike the yolk of an egg, and the coagulable lymph. That the blood is perfected from the fat by the proper powers of the fœtus, we are perſuaded from the example of birds. From it are inſenſibly prepared all the other humours; but all of them at firſt mild, void of taſte, colour and ſmell, and of a glutinous nature. The proper nature of every one of them approaches to that of ſerum; but ſome of them are not produced till many years after birth, for inſtance the ſemen.

DCCCCIV. The firm parts, even in a grown perſon, make much the ſmalleſt portion even of the harder parts of the human body; in the fœtus they differ from the fluids, by a ſomewhat greater degree of coheſion;

as yet, however, they are like a gluten, at firſt fluid, and afterwards more conſiſtent. In theſe the fibres which we could not diſtinguiſh in the primeval embryo are by degrees produced; the gluten, as it would ſeem, being ſhaken between the neighbouring veſſels, part of the water expreſſed, and the terreſtrial parts attracting one another. Theſe fibres variouſly comprehend one another, and form a cellular texture, even in diſeaſes, and intercept little ſpaces, in which there is a kind of humour. From this cellular ſubſtance are formed the membranes and veſſels, and almoſt the whole body.

DCCCCV. The veſſels are the oldeſt parts of the body, and are prepared in the firſt delineation of the embryo. What firſt appears in an egg during the time of incubation, having any diſtinct form, are venous circles: but theſe veins fabricate the arteries, by which they both receive their juice, and the motion of that juice. They are not generated mechanically from an obſtacle, as the arterial blood is found at that time. At firſt the trunks of the veins are conſpicuous, afterwards the branches which convey the humours to the trunks. If they were produced from the arteries reflected, the branches would firſt be ſeen, and the trunks formed in the laſt place. Neither could the arterial blood, driven back by an obſtacle, form thoſe moſt beautiful circles, and bring back the veſſels into the heart. It would rather flow irregularly through the cellular texture. And the primeval heart would ſoon loſe its life, unleſs as much of the humours returned to the heart as was ſufficient to keep up its pulſations.

DCCCCVI. There are, therefore, in the primeval fœtus, ſuch as we firſt obſerve it, ſome things more perfect and conſpicuous; others involved, inviſible, and very ſmall. The heart is the moſt perfect; it is the only moveable and irritable part; although it is in many reſpects different from what it is in an adult perſon. The brain is large and fluid; the veſſels formed which appear in the back next to the heart. The viſcera, muſcles, nerves, and limbs, are not yet to be ſeen;

the bones themſelves are preſent, of which the firſt appearance is a mucus, as are the veſſels of the reſt of the body. The other portion is that of the abdomen, the umbilical capſule of which is an immenſe hernia.

DCCCCVII. To this embryo is ſuperadded motion, in man almoſt of the heart alone; as alſo in birds, whoſe formation does not take place without heat rather greater than that of the human body: yet, without the heart, heat deſtroys, inſtead of forming the fœtus. It is the largeſt in proportion to the reſt in theſe beginnings; afterwards its proportion to the other parts of the body grows gradually leſs and leſs. Its pulſations are alſo at this time the moſt frequent, and in the ſofteſt fœtus the moſt powerful for impelling the humours, and diſtending and producing the veſſels.

DCCCCVIII. To the force of the heart is oppoſed what is of ſervice however in forming the fœtus, namely, the viſcidity of the vital humours which collect the earthy elements. There is therefore in the embryo both an impelling force, which increaſes the parts longitudinally; and a reſiſting force, which moderates the increaſe, and increaſes the lateral preſſure, and thus the diſtention. By the force of the heart all the arteries, but for eaſineſs of expreſſion we ſhall ſay only one artery, which repreſents all the reſt, with all its ſurrounding cellular texture, is lengthened out; its folds are ſtretched out, and the ſame artery is dilated. And the blood by its lateral preſſure makes an effort againſt the almoſt blind branches of the arteries, fills and evolves them, and ſets them off at more obtuſe angles: thus are produced ſpaces which make very little reſiſtance, in which the gluten is depoſited. In the very ſubſtance of the artery itſelf, while it is every where dilated, between its imaginable ſolid threads are prepared little reticulated ſpaces like a ſtretched-out net, which are equally fit for receiving humours. The largeſt of theſe are formed round the heart and in the head, whither the impulſe of the heart drives the humours in a ſtraight direction, and in the placenta: the leſſer ones are in the inferior part of the body, from which the umbilical arteries ſubtract the greateſt part of the blood.

DCCCCIX. The fœtus increaſes very quickly, as is moſt evident in the example of a chicken, whoſe length the twenty-ſecond day is to its length the firſt day at leaſt as 1,000,000 to 1; and the whole increaſe of bulk in the bird during the remainder of its life does not exceed the fifth part of the increaſe of the egg the firſt day. For the fœtus has a larger and more irritable heart, veſſels larger in proportion, and likewiſe more numerous and relaxed, and the ſolid parts are mucous and diſtenſible. The breaſt is later of coming to perfection, ſurrounded with membranes ſo ſoft, that they cannot be ſeen.

DCCCCX. The embryo does not only increaſe in bulk, but is ſo remarkably altered in ſhape, that it comes forth into the light totally diſſimilar from any thing that could be obſerved in it at its firſt formation. And firſt it is probable, that the articulations of the limbs are produced from the elongated arteries, that they are laterally knit together by a certain gluten, ſeparately evolved, and at firſt that they ſprout out very ſhort, but afterwards increaſe by inſenſible degrees, and appear divided into diſtinct articulations, as the wings of a bat are formed from an open vaſcular net-work. Thus likewiſe the right ventricle of the heart is expanded by the blood coming to it in greater quantity; and, being increaſed by degrees, equals the left.

DCCCCXI. On the other hand, the cellular texture, from its glutinous aqueous nature, by which earthy particles are continually brought to it, becomes inſenſibly harder; by a gentle attraction contracts its parts, which were before ſtraight, into various flexures; and ties the auricles to the heart, from which they were as yet at a diſtance. So the muſcles draw out proceſſes from the bones by their continual pulling, and open ſmall cavities into large cells: the ſame likewiſe incurvate the bones, and variouſly figure them.

DCCCCXII. Preſſure can do a great deal: to it we muſt attribute the deſcent of the teſticles into the ſcrotum, after the irritable force of the abdominal muſcles has taken place: to this alſo we muſt aſcribe the repulſion of the heart into the breaſt, when the integuments of the breaſt are larger: to it we are to aſcribe the length of the breaſt and the ſhortneſs of the abdomen, and the ſmaller ſize of the viſcera of the latter; becauſe the air received into the lungs dilates the cavity of the thorax. But even the bones are variouſly hollowed out by the preſſure of the muſcles, blood-veſſels, and even of the very ſoft brain itſelf; and by the ſame means fleſh is changed into a tendinous ſubſtance.

DCCCCXIII. The power of derivation brings the blood into the pelvis and lower extremities from the cloſed umbilical arteries: the ſame, when the foramen ovale is contracted by the auricles drawn towards the heart, evolves the right ventricle of the heart: when the veſſels of the yolk have taken up the whole length of the egg, and can receive no farther elongation, it dilates the umbilical arteries of the chick, and produces a new membrane with incredible celerity. On the other hand, but by the ſame power, after the blood has got an eaſy paſſage through ſome veſſels of any part, the other parts which do not afford a like eaſy paſſage increaſe the leſs. The head grows leſs after the lower limbs have begun to increaſe in bulk.

DCCCCXIV. A membrane may be formed from a humour of which the thinneſt part is exhaled, as we have an example in the epidermis: from the ſame may be formed a cartilage as happens in the bones, or even a bone itſelf, or ſomething of a ſtony nature, which is very frequent in the teſticles of aquatic animals. The bones at firſt are ſoft, and of a mucous nature; then they become of the conſiſtence of jelly; this afterwards becomes a cartilage; without any change made on the parts, as far as can be obſerved.

DCCCCXV. A cartilage, however, is not afterwards ſecretly changed into a bone. That never happens, unleſs lines and furrows have at firſt run along the cartilage: nay, the red blood has made a paſſage to itſelf through the veſſels of the bones; but theſe veſſels manifeſtly come from the nutritious trunks in the interior parts of the bone, and ſtrike as it were in right lines on the cartilaginous extremity of the body of the bone, which they remove farther and farther from its middle. Round theſe veſſels is formed a cellular texture and laminæ, which ſeem to preſs the veſſels themſelves towards the medullary tube. Laſtly, in the epiphyſis, which both remains much longer cartilaginous, and denies entrance to the blood, the red veſſels penetrate through the cruſt which covers the extremity, as well as the others which come from the exterior veſſels of the limbs. Thus alſo in the epiphyſis is produced a red nucleus of a vaſcular texture, which, being gradually increaſed by veſſels ſent out from its ſurface, changes the reſt of the cartilage into a bony nature.

DCCCCXVI. In theſe long bones it ſeems evident, that the increaſe is owing to the arteries elongated by the force of the heart, and gradually extended to the extremities of the bones: but that the hardneſs is owing to groſs particles at laſt depoſited in the cartilage when its veſſels admit the red blood. But even a bony callus never becomes ſound till the newly formed red veſſels have penetrated its ſubſtance.

DCCCXVII. The flat bones originate from ſomething of a membranaceous nature. Over this the fibres ſpread themſelves, at firſt in a looſe net-work, but afterwards they become more denſe, having the membrane for their baſis; the pores and clefts between theſe fibres being gradually contracted and filled with a bony juice, at laſt perfect the nature of the bones.

DCCCCXVIII. That a heavy bony juice, conſiſting of groſſer particles, is depoſited between the primeval fibres, is proved by the phenomena of the growing callus, which exſudes in ſmall drops, not from the perioſteum, but from the inmoſt ſubſtance of the bone, and is hardened by degrees. But even a chymical analyſis extracts that gluten from the bones; and in an anchyloſis it appears poured round the joint in a fluid, and manifeſtly fills up the chinks of the bones and intervals of the ſutures. It contains groſs earthy particles, which have been diſcovered by various experiments; and the juice of madder which adheres to it, manifeſtly diſtinguiſhes it by its colour.

DCCCCXIX. The perioſteum covers the bones, as a membrane does any of the viſcera; and from it cellular productions follow the interior veſſels of the bones: but, in the perioſteum, there are neither ſtraight fibres, nor an appearance of alveoli or laminæ, nor red veſſels, while the bone grows hard in the egg; nor does the perioſteum at all adhere to the bone, except in the epiphyſis, when it has aſſumed a bony nature in the middle; and it is thinneſt when the bone is in a cartilaginous ſtate, but every where complete. In the flat bones it every where affords a baſis for the bony fibres.

DCCCCXX. Therefore the head is large, every where membranaceous, in a few places cartilaginous on theſe firſt days of geſtation, with a mouth deeply cut, and long jaws. In the fœtus come to maturity, there are alſo rudiments of the teeth, which have a great deal of membrane as an appendage: the brain, at firſt fluid, and always ſoft, is itſelf very large, with large nerves: the eyes are big, and the pupil ſhut by a membrane: the breaſt is very ſhort, but capable of extenſion, on account of a great quantity of cartilage: the abdomen is large, ſurrounded with membranes, with a very large liver: the bile is innocent and mucous: the inteſtines are at laſt irritable, and full of ſoft, green, excrement, when the fœtus has now arrived at its ſtate of maturity: the kidneys are divided into lobes, are large, and have very big capſules: the pelvis is very ſmall, ſo that the bladder, ovaries, and tubes, project from it: the genital ſyſtem is denſe, not yet evolved, nor preparing its juices: all the glands are large, particularly the conglobate ones, and full of a ſerous juice: the ſkin is at firſt pellucid, then gelatinous, and at laſt covered with a ſoft cuticle and ſebaceous ointment: the fat is firſt gelatinous, and then grumous: the tendons ſoft, ſucculent, and not yet ſhining.

DCCCCXXI. There is a great difference betwixt the circulation of the blood in the fœtus and in the adult: that this may be underſtood, it is neceſſary to deſcribe the organs by which it is performed. The firſt is the *thymus*, a ſoft looſe gland, conſiſting of very many lobes, collected into two large upper horns, and two inferior ſhorter ones, which are however joined together by a great deal of long and lax cellular texture: this gland is large in the fœtus, and occupies a great part of the breaſt: it is ſeated in the cavity of the mediaſtinum, and part of the neck; and is wholly filled in its very inmoſt ſtructure with a white ſerous liquor, which cannot be diſcovered without wounding it. This gland, in an adult, being continually leſſened by the increaſe of the lungs, and by the aorta now become larger, gradually diſappears. What is the uſe of this gland or its liquid, we are altogether ignorant; but even all the other glands, eſpecially the conglobate ones, are larger in the fœtus than the adult, as we have juſt now obſerved.

DCCCCXXII. The cavity of the breaſt is ſhort in the fœtus, and greatly depreſſed by the enormous bulk of the liver; the lungs are ſmall in proportion to the heart, and ſo ſolid as to ſink in water, if they are every way excluded from taking the atmoſphere into their ſpungy ſubſtance, in making the experiment. Since therefore the like quantity of blood (CCXCII, CCXCVII.) which paſſes the lungs by reſpiration in adults, cannot be tranſmitted through the unactive lungs of the fœtus, who has no reſpiration, there are other ways prepared in the fœtus, by which the greater part of the blood can paſs directly into the aorta, from the lower cava and umbilical vein, without entering the lungs. In the primeval fœtus there is no right ventricle of the heart; and therefore there is ſuch a large opening of the right auricle into the left, that all the blood which comes by the vena cava immediately paſſes into the aorta, a very ſmall quantity excepted, which goes to the inconſiderable and inconſpicuous lungs. Afterwards in the fœtus, now grown bigger, the lungs are indeed larger, and the paſſage from the right part of the auricle into the left is narrower, ſeeing the auricular canal is now taken into the heart, and the auricles themſelves are become much ſhorter. But yet the ſeptum betwixt the right and left auricle, conjoining them together, is perforated with a broad oval foramen; through which the blood coming from the abdomen, and a little directed or repelled by the valvular ſides of the right auricle (LXXXVIII.), flows in a full ſtream into the cavity of the left auricle. But it is by degrees that the membranes of each ſinus depart from each other, upward and backward, above the oval foramen into the pulmonary ſinus, where they are connected on each ſide above, by ſeveral orders of fibres, which below are palmated or like fingers, ſo as to cloſe up at firſt a ſmall part, and afterwards a greater part, of this foramen, ſo as to leave only a ſmall oval portion of it at liberty; which lies free betwixt the round margin of the ſaid oval foramen and the increaſing valve, making in the mature fœtus about a fifteenth part of the area or capacity of the mouth of the vena cava.

DCCCCXXIII. That the blood takes this courſe in the fœtus, and that it does not on the contrary flow from the ſinus of the left to that of the right auricle, is evident, from all manner of experiments and obſervation[188]. For, firſt, the column of blood in the right

ſinus,

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[188] Contrary to this ancient opinion of Galen and Harvey, which almoſt all the moderns, except Mery and Winſlow, have adopted, Mr Wolf has raiſed great doubts; and, as he goes upon diſſection, has ſubſtituded an ingenious and not improbable opinion. When he found that there was one foramen ovale in the right ſide formed by Vieuſſens's arch and Euſtachius's valve, and another in the left ſide formed by the ſame arch and foramen ovale, theſe ſinuſes in this way never could communicate. He therefore found, that the inferior vena cava, which opened both into the right ſinus and into the left, and poured a part of its blood into each ſinus, the valve of the foramen ovale being diſſected, was interpoſed between the ſinuſes, the left

more

ſinus, is of all the largeſt; and, as it is the returning one from the whole body, cannot be exceeded by any other: but the left auricle has ſo much leſs blood in proportion than that of the right, inſomuch as part of it flows throw the duct or canalis arterioſus into the aorta, whence its contents will be much leſs than that of the right auricle: moreover, the valve of the oval foramen, in a mature fœtus, is ſo large, and placed ſo much to the left of the muſcular arch or iſtmus (DCCCCXXII), that when it is impelled by the blood from the left ſide, the valve, like a palate or ſhutter, cloſes up the foramen; but being impelled from the right ſide, it readily gives way ſo as eaſily to tranſmit either blood or flatus, but it will retain even flatus itſelf when injected from the right, nor will it ſuffer it to paſs back again to the right ſide.

DCCCCXXIV. Moreover, there is but a ſmall portion of the ſame blood, which firſt entered the right auricle and ventricle of the heart, that takes its courſe through the lungs: for the pulmonary artery, being in the fœtus much larger than the aorta, is directly continued into the ductus arterioſus; which is larger than the light of both the pulmonary branches together, and greatly larger than the opening of the foramen ovale, and enters that part of the aorta which comes firſt in contact with the ſpine, under its left ſubclavian branch: by which means it transfers more than half the blood to the deſcending aorta, which muſt otherwiſe have paſſed through the left auricle and ventricle into the aſcending branches of the aorta; and this is the reaſon why the aorta in the fœtus is ſo ſmall at its coming out from the heart. By this mechaniſm an overcharge of blood is turned off from the lungs, by directing a great part of that

more than the right, which he obſerved in heifers ſomewhat more accurately than in man. That portion of blood, therefore, which penetrates through the orifice of the inferior vena cava into the right ſinus, ſtraightway paſſes with the blood of the ſuperior vena cava into the right ventricle: But that portion of the blood which runs through the orifice of the inferior vena cava into the left ſinus, without touching the lungs, goes into the left ventricle with the blood of the pulmonary veins.

that fluid in a ſtraight courſe to the umbilical arteries, and the powers of both ſides of the heart are united in propelling the blood.

DCCCCXXV. Thoſe who have aſſerted that the fœtus reſpires in the uterus, having made very few experiments, have neglected that moſt eaſy one which is made by water, in which the fœtus will ſwim; and likewiſe by the lungs, which in a fœtus are conſtantly heavy, and ſink in water: laſtly, they do not attend to the evident ſhortneſs of the breaſt, and ſmallneſs of the lungs. Whether or not it can take in air through the vagina of the mother, is very difficult to be determined: and I ſuſpect it to be poſſible in a certain ſituation, that a well-grown fœtus, which is not too much compreſſed, may ſometimes draw in air, while it ſticks by a part of its body, between the parts of its mother.

DCCCCXXVI. As the fœtus grows larger, ſo the uterus increaſes proportionably; the ſerpentine arteries of which it is compoſed being extended by the impelled blood, and ſtretched into a more direct courſe; while the veins having their trunks compreſſed by the great bulk of the uterus, and being unable to return the blood, ſwell out into immenſe ſinuſes; and laſtly, from the menſtrual blood retained in the uterus, and not yet quite ſpent on the fœtus. Thus its thickneſs continues the ſame, becauſe the greater quantity of blood and dilatation of the arteries and veins make up for the extenuation of its ſolid parts. But more eſpecially the fundus, or upper part of the womb, increaſes beyond the reſt; ſo that, by dilating the above tubes, theſe laſt ſeem thus to deſcend from the middle of the uterus, which now by degrees goes out of the pelvis, even as high as the colon and ſtomach itſelf, ſo as to compaſs all the abdominal viſcera, more eſpecially the bladder and rectum. The os uteri in the firſt months of geſtation is drawn upwards with the uterus itſelf, and recedes from the entrance of the vagina: after the third month, however, it again deſcends, and ſtretches into the vagina[189]. The ſame becoming perpetually ſhorter, projects upon the cloſe extremity of the vagina: it is, however, conſtantly tender; and, from that cartilaginous hardneſs which is obſerved in the virgin womb, is relaxed into a mucous ſoftneſs. It is never perfectly cloſed or ſhut together, but only ſtopped up and defended from the air by thick mucus from the ſinuſes, and perhaps from the veſicles which are ſeated in the cervix uteri. Moreover, the cervix or neck of the womb itſelf, which has long remained unchanged during the laſt months of geſtation becomes likewiſe ſhort, and forms a broad flat opening, of no length; which, towards the time of delivery, is always more or leſs relaxed and gaping. As theſe matters advance, the fœtus, which in the firſt months had no certain ſituation, being now grown to a conſiderable bulk, is, about the middle of the time of geſtation, folded together into a globe, in ſuch a manner that the head lies betwixt the knees; and being the heavier part, it ſubſides by degrees more and more into the pelvis towards the cervix uteri.

DCCCCXXVII. The various complaints in the uterus are now increaſed to the higheſt degree, being diſtended by the great quantity of blood retained in it; for nothing is more diſagreeable to a human creature than a violent tenſion, unleſs it is done very gradually. From the head of the fœtus ſinking down into the pelvis, the rectum, bladder, and that part of the uterus next the neck, and which is the moſt ſenſible, are preſſed, and become painful: the fœtus, having received its full increaſe of bulk, diſtends the uterus every way; and that with the greater uneaſineſs, becauſe, the waters being now taken away, the limbs which are fully formed, and the head, preſs much more vehemently on the uterus. It is thought alſo that the placenta itſelf, now very large, diſtracts the internal and naked ſurface of the uterus. From theſe cauſes ariſe at firſt ſlight endeavours of the uterus to free itſelf; and at laſt, when theſe cauſes are now got to their utmoſt height, ſuch an uneaſy ſenſation is occaſioned by the impacted head of the fœtus as ariſes from a collection of feces in the rectum; by which pain, therefore, the mother is conſtrained to attempt the birth of the child. The time of delivery comes on after the expiration of nine ſolar months, and is kept pretty exactly in every ſpecies of animals, although by ſome cauſes it may be accelerated or retarded for ſome weeks, according to the nature of theſe cauſes, whoſe power, however, we muſt not extend too far.

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[189] The aſcent of the uterus is continued for almoſt four months and a half, ſo that it is out of reach of the finger. In the beginning of the ſixth month it again begins to fall, and may be more eaſily reached by the finge

DCCCCXXVIII. The teneſmus thus increaſing till it is no longer tolerable, the mother uſes all her efforts by very deep inſpirations, which preſs downwards the uterus and viſcera of the abdomen (DCCLVI.); and at the ſame time the womb itſelf, by its contractile vital force, conſtringes itſelf ſo powerfully about the fœtus, as ſometimes to exclude it, without further efforts from the mother. The difficulties of the birth, however, are evidently overcome principally by the efforts of the mother, while the mouth of the uterus, now very ſoft, ſuffers itſelf to be diſtended by the head of the fœtus. Now the amnios, filled with the water, is firſt protruded vertically, before the head of the fœtus, ſo as to dilate the os internum uteri; in which, the membranes being by degrees extenuated and dilated, eaſily break, and pour out their waters, which lubricate the paſſages, and relax all the parts of the vagina. The naked head of the fœtus now preſents naturally with the face to the os ſacrum, directed that way by its weight: and being urged forward, like a wedge or cone, it further dilates the os uteri; till at length, by the more powerful efforts of the mother, which often looſen the bones of the pubes in young women, the head is thruſt out through the dilatable vagina, with intolerable pain to the mother, and an univerſal tremor of body; and if none of the bones of the pelvis happen to preſs unequally, the infant eaſily advances, and is delivered into the world. This happens difficultly even in quadrupeds; but moſt of all in the human race, whoſe fœtus has the largeſt head in proportion to its body.

DCCCCXXIX. It is natural for women to have but one child at a birth, which law they have in common with all the larger animals, unleſs they are of the carnivorous kind. Frequently, however, they have two[190], more rarely three, and ſcarce ever five. It is not to be doubted, however, that a ſecond fœtus may be conceived while the firſt remains in the uterus; ſeeing women have frequently born children, when a hard and oſſified fœtus had been for a long time retained in their uterus.

DCCCCXXX. The placenta of the fœtus, connected with the fundus uteri (DCCCLXXXVIII.), is, in the next place, ſeparated from the womb, without much difficultly in a mature birth, partly by the weaker throes of the mother, and partly by the extracting force of the deliverer; by which the fleecy or villous ſurface of the placenta being withdrawn from that of the womb, is immediately followed with a conſiderable flow of blood; and thus is the mother delivered from the ſecundines or after-birth. The umbilical cord of the fœtus is next tied, before it is cut off; for it cannot be left open, without danger of a fatal hemorrhagy. Thus the umbilical vein is deprived of all the ſupplies of blood which it uſed to receive, and at the ſame time an inſuperable obſtacle is oppoſed to the blood, conveyed by the arteries of the ſame name.

DCCCCXXXI. The uterus, which hitherto had been diſtended beyond imagination, now contracts itſelf by the elaſtic power of its fibres (DCCCXLIII.), ſo ſuddenly and powerfully, as often to catch and embarraſs the hand of the deliverer, and frequently retain the placenta,

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[190] Twins are conceived in the uterus more frequently than is generally believed, although one is often deſtroyed, and comes away with the ſecundines without any perſon's notice: but the proportion of thoſe which come to the full time is as 1 to 60 or 65.

ta, if it be not ſoon looſened and withdrawn. By this contraction of the womb, the bleeding veſſels are compreſſed, no leſs than by the contraction of their own coats; whence the large quantity of blood that was collected in the uterine ſubſtance abundantly flows out, under the denomination of the *lochia;* at firſt a mere gore, but afterwards, as the openings of the veſſels more contract themſelves, they firſt become yellow, at length become of a whitiſh or wheyiſh complexion; and then the ample wound of the uterus is ſoon healed, and ſhrinks up to a bulk not much exceeding that of the virgin uterus.

DCCCCXLIV. But after two or three days are elapſed from the birth, when the lochial diſcharge has almoſt ſpent itſelf, the *breaſts* begin to ſwell conſiderably; and their ducts, which in the time of geſtation often diſtil a little thin ſerum from the nipple, become now very turgid with a liquor, which is at firſt thin or like whey, but is ſoon after followed by the thicker chyle itſelf. For *milk* very much reſembles chyle, but human milk leſs than that of other animals. It is white, thickiſh, ſweet, and replete with a very ſweet eſſential ſalt, which grows ſour ſpontaneouſly, but is tempered by the oil and lymph added to it. It has alſo a volatile and ſomewhat odorous vapour, a good deal of fat or oily parts, a larger portion of a white craſſamentum or cheeſy curd, and ſtill more of a diluting water; and again, in the craſſamentum, are contained parts of a more earthy, alkaleſcent, or animal nature[191]. But when the chyle is once changed into ſerum, by faſting a conſiderable time, the milk becomes brackiſh, alkaleſcent, and diſpleaſing to the infant. As the chyle, ſo the milk frequently retains the nature of the aliments and medicines taken into the ſtomach. The cauſe of this increaſed ſecretion in the breaſts,

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[191] Milk in its ingredients does not differ much in many animals: but no milk reſiſts acids ſo ſtrongly as the human. It is alſo leſs readily coagulated than aſs or cow milk by alkalis. Alum poured upon woman's milk leaves it untouched; but lime-water coagulates it. The experiments of Hahn and Voltolen, which were made after Spielman's obſervations, are very elegant.

breaſts, ſeems owing to the revulſion, in conſequence of the plentiful uterine ſecretion being ſuppreſſed, by which the fœtus was nouriſhed; in the ſame manner as a diarrhœa is ſuppreſſed by increaſing the perſpiration. For it has been obſerved, that true milk will ſometimes make its way through other parts beſides the breaſts, and even eſcape through wounds. And there is otherwiſe between the uterus and breaſts ſome kind of nervous ſympathy, and a ſimilar fitneſs for generating a white liquor. For the uterus in infancy, and during the time of pregnancy, manifeſtly generates it. But the inoſculations betwixt the mammary and epigaſtric arteries, though true, are ſo ſmall, that they can have but a very little ſhare in this account.

DCCCCXLV. The *breaſts* are made up with a very large quantity of ſoft ſurrounding cellular fat, of a white colour; and conglomerate glandules, of a convex figure, aſſembled into bunches ſomewhat round and hard, of a reddiſh blue colour, outwardly ſurrounded and connected by a firm web of the cellular ſubſtance, ſeparating off into leſſer kernels, which are common both to men and women. To theſe glandules a great number of blood-veſſels are diſtributed from the internal mammaries, from the external veſſels of the thorax, and ſometimes from thoſe of the ſhoulders, all which inoſculate together around the nipple[192]. The trunks of the mammary arteries, but not the *mammales*, inoſculate with the epigaſtric veſſels, but the veins more evidently. The nerves are both large and numerous, like thoſe of the more ſenſible cutaneous parts, being derived from the ſuperior intercoſtals.

DCCCCXLVI. From the middle of this gland of the breaſt, and likewiſe from the ſurrounding fat, an infinite number of ſmall ducts or roots ariſe, very ſlender, ſoft, white, and dilatable, which come from all ſides to the middle of the nipple, and likewiſe into the circle which ſubtends its baſis, and then run together on the area of that circle, and emerge at the root of the nipple, which they perforate round its margin, in a circular figure, after emerging through the root of the ſaid *papilla* or nipple; for by this denomination we call a cavernous or ſpungy cellular body, into which the blood may paſs out from its veſſels, ſo as to cauſe a kind of erection, as in the penis. Through this papilla open about twenty or more of the excretory ducts from the breaſt, called *lactiferous;* none of which inoſculate[193] or join with the others, but are greatly contracted at their opening in the nipple, to what they were in the breaſt: and theſe, in a looſe or flaccid ſtate of the nipple, are compreſſed, wrinkled, and collapſed together; but when the nipple is erected by any kind of titillation, they become ſtraight and open, with patulent mouths, lurking betwixt the cutaneous wrinkles. This papilla or nipple is ſurrounded by a circle, planted with ſebaceous ſmall glandules, which defend the tender ſkin againſt the repeated attrition and perpetual moiſture.

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[192] In order to underſtand the true ſtructure of the female mamma we muſt compare the pretty deſcriptions of Walter and Kolpin with Cubol's obſervations according to Santorinus.

DCCCCXLVII. Thus the infant is naturally provided with its firſt food, which is otherwiſe exceedingly ſalutary to man. This the infant by inſtinct knows how to receive, although it is as yet a ſtranger to all the other

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[193] Theſe lactiferous ducts have now been ſo completely and elegantly deſcribed by Meckel and Walter, and likewiſe delineated according to Santorinus, Cubol, and Gerard, that this viſcus, except its lymphatic veſſels, ſeems to be almoſt diſtinctly known. However, theſe famous anatomiſts diſagree; ſome being uncertain whether the lactiferous ducts communicate, which Meckel ſuppoſed, or not, as Cubol, Walter, and Gerard have thought. Whatever experiments I have made with mercury or wax, I was convinced that no ſilver iſſued from the nipple, if I filled one duct; but I muſt not deny, that in a few examples the mercury returned through one or other orifice of the nipple. I have even this winter remarked a double ſet of lymphatic veſſels with which the mammæ abound; moſt of which, gradually collected into a great plexus, go to the axillary glands; but others enter the thorax, through the interſtices of the ribs, in the neighbourhood of the ſternum, and communicate with the conglobate glands of the breaſt, ſituated behind the mammary veſſels.

offices of human life. Taking the nipple in its mouth, it cauſes it to ſwell by gentle vellications; the lips are preſſed cloſe to the breaſt, that no air may enter betwixt; at the ſame time the inſpiration is deep, and a ſpace formed in the back part of the mouth, in which the air is more dilated or rarefied; and thus, by the preſſure of the external air, joined with that from the lips of the infant, the milk is urged from the breaſt thro' the nipple, in which it would otherwiſe be collected in ſo great a quantity, as ſometimes to diſtil ſpontaneouſly and be very ready to flow out; and thus the infant ſucks, and is nouriſhed. The firſt milk, which is like whey, termed *coloſtra*, looſens the tenders bowels of the infant, and purges out the meconium (DCCCXCVIII), to the great advantage of the infant. Yet it is alſo obſervable, the lactiferous ducts are ſo open, that when the nipples of the breaſt are diſtended by titillation, and a greater quantity of blood ſent into the breaſts, they have yielded milk, even from virgins, ſometimes from old women, or even from men. Milk is only generated after puberty; before that a time a ſerous humour flows from the breaſt; and for the moſt part it is generated only about the middle of pregnancy. After the menſes have ceaſed, the breaſts, as well as the uterus, become decayed, and ceaſe to perform their office.

DCCCCXLVIII. But great changes now happen to the little new-born infant; and the firſt is *reſpiration*, which it endeavours to exert, even before it is well ſet at liberty from the vagina of the mother, being probably excited, from the pain or anguiſh it feels, to thoſe cries with which it ſalutes the light, and perhaps from the deſire of food which it had hitherto taken in from the liquor of the amnios. At firſt, therefore, a portion of the air is admitted into the lungs, which are as yet ſmall and full of moiſt vapours; but being dilated from the air, change from a ſmall denſe body, ſinking even in ſalt water, into a light ſpungy floating fabric, extended to a conſiderable bulk with air, and of a white colour. Now, therefore, the blood paſſes more eaſily into the enlarged and looſe fabric of the lungs (CCLXV.); in conſequence of which, a large portion of the blood that went before from the pulmonary artery, through the canalis arterioſus, into the aorta, goes now into and through the lungs themſelves, by the other branches of the ſaid pulmonary artery. And ſo much the more is the arterial duct or canal deſerted, inaſmuch as there is made a new obſtacle to the deſcent of the blood into the abdomen; for the umbilical arteries being now very ſtraitly tied, the blood of the deſcending aorta cannot now find its way but by the ſame force with which it dilates all the arteries of the pelvis and lower extremities. Finally, as the lungs now receive more blood, ſo the aorta itſelf receives a greater quantity, and with greater force likewiſe from the heart; whereupon the intermediate canal, betwixt the protuberant part of the aorta and pulmonary artery, cloſes up or ſhrinks to ſuch a degree, that, in adults, it is not only an empty ligament, but likewiſe of very little length; and otherwiſe it is ſingularly red in the inner part, ſoft, and very fit for concreting with the ſtagnating blood. This courſe of the blood, therefore, is ſoon aboliſhed, commonly in about the compaſs of a year.

DCCCCXLIX. In the like manner alſo, the foramen ovale is, from the ſame cauſes, gradually cloſed up. For when the way is rendered more free and pervious into the lungs, it will likewiſe be more free into the right ſide of the heart; whence the blood, both of the aſcending and deſcending cava, will flow thither more plentifully, as it is invited by the more lax pulmonary artery, into which it will rather move, than through the paſſage through the ſeptum of the ſinuſes. Again, the umbilical vein, being now almoſt deſtitute of any ſupply with blood from the ligature of the navel (DCCCCXXX.), leſs blood will from thence flow into the lower cava, and conſequently the preſſure againſt the oval mouth will be diminiſhed; by which means the blood of the upper cava, being turned off by the iſthmus, will be ſcarce able to penetrate the obliquity of the foramen ovale. Thence again, as more blood is derived through the lungs into the left ſinus and auricle, its greater dilatation and extenſion will ſtrain the little horns of the oval valve, ſo as to draw up and preſs the valve, together with the iſthmus, whereby it is extended ſo far, as wholly to ſhut up the opening in the mature infant, while, at the ſame time, the blood, within the left ſinus, props up the ſaid valve, ſo as to ſuſtain the impulſe of the blood on the other ſide within the right ſinus. Thus, by the acceſſion of a little friction of the uppermoſt margin of the valve againſt the upper part of the iſthmus, the foramen ovale cloſes up by degrees, and the upper margin of the valve forms a concretion to the poſterior face of the iſthmus. But this is performed very ſlowly; inſomuch that frequently, in an advanced age, there will be ſome ſmall aperture or tube ſtill remaining; and where there is none of this tube, yet there are the remains of one, as a kind of ſinus, hollow to the left ſide, that makes a tube opening upward to the right ſide, and blind or cloſed to the left, becauſe the power of the blood in the right ſide is always greater than its reſiſtance on the left, or certainly not leſs, even in the advance of life.

DCCCCL. The *umbilical vein*, being deprived of blood, ſoon cloſes up. The blood of the vena portarum, having no oppoſition from that which formerly flowed through the umbilical vein, occupies the left ſinus and curve of the umbilical foſſa (DCXCV.), and ſends its blood through thoſe branches by which that of the umbilical vein before paſſed. Thence the *ductus venoſus* being neglected, ſhrinks up and cloſes, by the new compreſſure which the deſcending diaphragm makes upon the liver by inſpiration; and by which the left lobe of the liver is preſſed towards the lobule, and perhaps too from the obtuſe angle which it makes with the left ſinus of the vena portarum; for it is certainly firſt cloſed in that part which lies next the vena portarum.

DCCCCLI. The *umbilical arteries* are alſo cloſed up from the ſame cauſes, as other arteries uſually are after a ligature, when ſome of the blood being at the ſame time compacted into a polypus, fills up the blind void part, while the other blood, flowing above, whoſe impulſe was ſuſtained by the reſiſting membranes, ſpreads itſelf through the adjacent leſs reſiſting branches, which are thereby rendered more open or diverging. Nor do I overlook the force of the abdominal muſcles towards this effect, by which thoſe arteries are compreſſed againſt the full abdomen in each reſpiration; and, again, the very acute angle in which the umbilicalis goes off from the iliac artery, now becomes a curve, by deſcending with the ſides of the bladder, and is then directly extended into an acute fold, which the thighs make with the body of the fœtus. Thus the capacity of theſe arteries is ſoon ſhut up, leaving only a ſmall tube, that gives paſſage into two or three arteries of the bladder. The *urachus* being likewiſe a very thin tube, extended perpendicularly upward from the bladder, is therefore eaſily cloſed up; ſo that the contents of the bladder make no endeavours to paſs that way, finding a ready outlet by the deſcending urethra.

DCCCCLII. From the like cauſes the bulk of the liver itſelf is leſſened, and by degrees contracts itſelf within the capacity of the ribs; in the mean time the inteſtina craſſa, from the ſlender condition in which they are obſerved in the fœtus, dilate to a conſiderable diameter, and the ſtomach itſelf is gradually elongated; the large convexity of the cæcum forms itſelf by the force of the feces preſſing perpendicularly downward to the right ſide of the vermicular appendix; and the lower limbs are likewiſe conſiderably enlarged by the return of the blood, ſent back from the umbilical arteries now tied; and by degrees all the other changes are made, by which a fœtus inſenſibly advances to the nature and perfection of an adult perſon.

CHAP. XXXII.

Nutrition, Growth, Life, *and* Death.

DCCCCLIII. AFTER birth the child continues to grow, but always more ſlowly the older it is. There are many concurring cauſes, why the growth is continually rendered leſs and leſs. Many veſſels ſeem to be ſtopped up, both becauſe they are compreſſed by the neighbouring torrent of blood flowing through the great arterious tube, and becauſe the blood being now become more viſcid runs into clots. But the harder kind of food that is now made uſe of, throws into the blood more terreſtrial parts, which being carried through the whole body along with the nutritious parts, renders them all harder, as the bones, teeth, cartilages, tendons, ligaments, veſſels, muſcles, membranes, and cellular texture; ſo that an increaſe of hardneſs may be perceived in them, even by touching them with the finger. Wherefore, ſeeing the blood flows from the heart through fewer canals, and ſeeing all parts are grown harder, which ſhould be lengthened or diſtended, it neceſſarily follows, that thoſe which ought to increaſe in bulk, will yield leſs and leſs to the impulſe of the heart.

DCCCCLIV. But the heart likewiſe, which is the part that is firſt conſolidated among all the ſoft ones, increaſes leſs than any other part of the whole body; and while the much more tender limbs and ſofter viſcera are diſtended, the proportional bulk of the heart to the reſt of the body grows continually leſs and leſs, till at laſt its proportion to the body of the adult becomes eight times leſs than what it was in the new-born infant. At the ſame time, from that very denſity which it has ſo quickly acquired, it becomes leſs irritable, and is contracted leſs frequently within a given time. Thus, while the reſiſting forces are augmented, the diſtending ones are at the ſame time diminiſhed.

DCCCCLV. There will therefore, ſooner or later, be

BRITISH MUSEUM 30 NOV 67

an end of the increaſe of bulk; and that will happen ſo much the ſooner as the heart has had the more frequent and vivid contractions: but this ceſſation of growth will take place when the cartilaginous cruſts of all the bones are now become ſo thin that they cannot yield to the increaſe of the bony part. In women the menſes ſeem to put a ſtop to the growth ſooner than in men. In cartilaginous fiſhes, there is perpetual growth.

DCCCCLVI. There is no ſtate in which nature by a perennial progreſs induces a continual decreaſe from the firſt conception. It is ſaid however to take place, when there is neither any increaſe of bulk, nor yet does any viſible decreaſe take place.

DCCCCLVII. For we are all perpetually conſuming (CCCCXXXIV). Nor do we only loſe the fluid parts of our bodies, but in ſhort even thoſe which are reckoned to be the moſt ſolid. For even the bones are changed; and the teeth, which are harder than the bones, increaſe in bulk when the attrition of the oppoſite teeth has ceaſed to wear them away, and therefore their elements are changed: even the fibres of ivory in the elephant's teeth have quitted their places, and ſurrounded on each ſide in curve lines a leaden ſhot: the bony juice likewiſe is changed; ſeeing in ſome caſes the bones grow ſoft, in others they ſwell out in bony tumours: even cicatrices themſelves have a manifeſt growth, otherwiſe they would not be ſufficient in an adult perſon to cloſe up a wound which he had received, when a boy; and a great quantity of the earthy part of our bodies goes off by urine, as is proved by ſome diſeaſes.

DCCCCLVIII. The cauſe of the deſtruction of the ſolid parts lies in their perpetual extenſion and retraction, which happens at every pulſe of the heart: this occurs an hundred thouſand times every day, and by this motion even metals themſelves are worn. Other cauſes are from the friction of the fluid againſt the ſolid parts; from the wearing away of all the membranes, which terminate with a moveable extremity, either on the ſurface or in the internal cavities of the body, the firmneſs of which only belongs to the reſt of the canal; in the alternate ſwelling and decreaſe of the muſcles; and in the attraction and preſſure which at firſt form our fleſhy parts. But all parts of our body are the ſooner worn away, that they conſiſt of a great deal of gluten combined with a ſmall quantity of earth; and that gluten when it is extended, if the extenſion has been a little ſuperior to the force of its coheſion, muſt of neceſſity fall away and be carried off from the earthy parts. Thus wrinkles or furrows are generated; ſuch as are viſible in the arteries of old men. The cellular texture, which otherwiſe would be diſſolved into water or gelly, is worn away by the impetus of the blood preſſing againſt the neighbouring blood-veſſels and muſcles, by friction, and by perpetual flexion and extenſion.

DCCCCLIX. The decreaſe would be very quick, and indeed there would be no great diſtance between the end of our life and its beginning, unleſs theſe loſſes were repaired. The fluid parts are reſtored by the aliments, and that pretty quickly; as appears from the example of a chicken, in which blood is generated out of its aliment within two days. The fat, however, and red globules of blood, are formed out of the fat, as is ſhown elſewhere; the lymphatic juice from jelly; the mucus from mucus; and the reſt of the humours from theſe and water. The ſolid parts are repaired almoſt by the ſame methods which we have deſcribed in the hiſtory of the fœtus. A gelatinous juice is brought from the aliments, through the arteries, to all parts of the body, and exſudes into all parts of the cellular texture. The furrows, which we might imagine to be made in the inmoſt arterial membrane by the impetus of the blood, are filled up by a viſcid matter brought into them by the lateral preſſure; nor is it poſſible that theſe furrows can be overfilled, becauſe every exuberant particle of nutritious juice muſt neceſſarily be carried off by the current of the blood. This will not be wanting while there is a ſufficient quantity of aliment;

while there is more reſt, and leſs reſiſtance, in the bottom of the furrow than elſewhere, which always muſt be the caſe, becauſe the bottom is farther removed from the motion of the blood by the depth of its cavity. There ſeem to be certain powers in the air[194], by which the aliment is attached to the ſolid parts, although we are ignorant of the manner in which they act.

DCCCCLX. The decreaſe of the cellular texture ariſing from attraction or preſſure, will be repaired by the viſcid vapour exhaling from the artery, and preſſed towards thoſe places which ſtand in need of reparation by the force of the neighbouring arteries and compreſſing muſcles, its aqueous part being preſſed out and reſorbed. The gluten repairs moſt of the organic parts, tendons, and membranes; being formed into a new cellular texture, as in the fœtus.

DCCCCLXI. The waſte which takes place in moveable parts adhering by their other extremity to the reſt of the body, can be repaired by protruſion alone, while the lymph fills up the intervals or hollows that are thus produced.

DCCCCLXII. At that time when the growth of the body can proceed no farther, fatneſs is produced, which is a kind of imitation of real growth. This proceeds from the fat generated by the aliment; which by reaſon of the impetus of the blood being leſſened, and its entering the ſmalleſt veſſels with more difficulty, is carried to the ſides of the veſſels; enters the lateral ones and the inorganic pores of the arteries; exſudes into the cellular texture; and there, the power of conquaſſation of the blood being now diminiſhed, and likewiſe the abſorption by the veins, the fat is conſequently collected.

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[194] It was formely rendered probable by Hales, that air contributed greatly to the coheſion of bodies: and this doctrine has been lately confirmed by Achard's experiments, by the application of fixed air to form cryſtals. Prieſtley and Ingenhouz have proved unqueſtionably, what ſervice, in general, the air and its different particles do in the buſineſs of nutrition.

DCCCCLXIII. We feel the beginnings of decay even in youth itſelf. Even in that blooming ſeaſon the ſolid elements of the body are augmented, the chinks through which the humours flow are leſſened, ſmall veſſels filled up, and the greater attraction of the cellular texture has added a denſity to the whole body. Throughout the whole body that hardneſs occaſioned by age is very conſpicuous, in the bones now wholly brittle, in the ſkin, in the tendons, in the conglobate glands, in the arteries, and likewiſe in the weight of all the parts, and of the brain itſelf. But thoſe parts grow ſtiff ſooneſt which are moſt exerciſed by motion; as thoſe in every mechanic, which he chiefly makes uſe of in his buſineſs.

DCCCCLXIV. Moreover, the arteries alſo continue to become more denſe, more narrow, and even to be quite filled up, as well by the internal preſſure of the blood flowing through the large arterial tube, as from the attraction of the cellular texture of which the greateſt part of the artery is made up. An infinite number of parts of the cellular texture thereof ceaſe to be nouriſhed; to which the ſmalleſt arteries hitherto brought their nouriſhment, but now when ſtopped up can bring none. The extending force being removed, the cellular fleeces draw themſelves together, contract the little ſpaces intercepted between them, degenerate into membranes, or ſubſtances of a hard texture, which intercept and as it were choak up other veſſels. But the gelatinous vapour likewiſe concretes in the ſmall hollows of the cellular texture, and unites into a hard ſolid with its ſides. The muſcles, having expelled the blood they contained, and condenſed their fibres, degenerate into hard denſe tendons deſtitute of all irritable power.

DCCCCLXV. At the ſame time the nerves become more and more callous to the impreſſions of the ſenſes, and the muſcules grow leſs ſenſible to the ſolicitations of the animal powers; thus the contractile force of the heart, and the frequency of its pulſations, is diminiſhed, ed, and therefore the whole force which drives the blood into the ſmalleſt veſſels.

DCCCCLXVI. The quantity of humours is diminiſhed in a denſe body, as is evident in the perſpiration, ſemen, humours of the eye, and of the conglobate glands; the vapour alſo which bedews the ſolid parts of the body, every where decreaſes. For this reaſon nutrition now languiſhes, becauſe there are more parts of the body which require nouriſhment, and leſs nutritious juice.

DCCCCLXVII. Nor is the quantity of humours only diminiſhed: they themſelves are likewiſe corrupted. They were mild and viſcid in children: but theſe ſame humours are now acrid, ſalt, fetid, with a great quantity of earth, in old men. This happens through the uſe of ſalt or putrid aliments, the fault of which grows ſtronger by being collected through a great length of time; alſo through the fault of a leſs perſpirable ſkin, a coſtive belly on account of the diminiſhed irritability, and thus the increaſed reſorption of the putrid liquamen. Hence the fetor of the urine, of the breath, and the difficult healing of wounds.

DCCCCLXVIII. But the greateſt fault of the humours is, that they abound with earthy particles, as well thoſe collected inſenſibly from the aliments after the ſecretions have become leſs free, as from thoſe which are carried off from the ſolid parts and returned into the blood: of this conſiſts the earth collected in ſome diſeaſes, and which is of the nature of the gouty earth. By this quantity of earth, the portion of that element through the whole body is augmented, becauſe the nutritious liquor brings too much of that along with it; whence the brittleneſs of the bones, and the hardneſs of all the other parts, increaſes: the ſame is likewiſe every where depoſited in the cellular texture, and produces cruſts, which are firſt callous, then of a bony or ſtony nature, and that chiefly in the coats of the arteries.

DCCCCLXIX. The hardneſs or rigidity of the whole body, the decreaſe of the muſcular powers, and the weakening of the ſenſes, conſtitute *old age;* which happens to mankind ſometimes ſooner, and ſometimes later: ſooner if they have been ſubjected to violent labour, or given themſelves up to pleaſure, or lived upon unwholeſome diet; but more ſlowly if they have followed a moderate way of life, and uſed temperance in their diet, or if they have removed from a cold to a warm country[195].

DCCCCLXX. But when thoſe cauſes continue to operate by rendering the matter of the body more denſe, by diminiſhing its irritability, and augmenting the quantity of earth, it is not poſſible but decrepid old age muſt ſucceed. In it the ſenſes are almoſt deſtroyed, the natural power of the muſcles is exceedingly weak, the limbs loſe their ſtrength, the feet eſpecially are not ſufficient for ſupporting and directing the body. Thus the callous inſenſibility of the nerves cannot be incited to perform the office of generation: thus the very inteſtines becoming inactive, refuſe to anſwer to the accuſtomed ſolicitations: thus alſo, by the induration of the cartilages interpoſed betwixt the vertebræ, the body bends forward; by the falling out of the teeth, the jaws now rendered ſhorter cannot ſupport the lips as uſual; and laſtly, the heart loſes one half of the frequency of its pulſation which it had in the infant ſtate.

DCCCCLXXI. Thus at laſt natural death neceſſarily follows; but very many people are carried off before this time by diſeaſes. Scarce one in a thouſand exceeds the age of 90; but one or two perhaps may be found in a century that live to the age of 150. Man is long lived when compared with other animals; he is alſo more tender than any of them, has looſer fleſh, and leſs hard bones. Among the long-lived people, it is not eaſy to ſay what was the cauſe of that privilege. England ſeems to excel all other nations in the long-lived people; and generally the temperate countries are remarkable in this reſpect. Among all the different profeſſions, the commonalty has almoſt ſolely afforded theſe rare examples of longevity already mentioned; although from the more numerous claſs, we might expect a greater number of examples. Some prerogatives of long life ſeem to be ſobriety, at leaſt a moderate and not very rich diet; a mild behaviour; a mind not endowed with very great vivacity, but cheerful, and little ſubject to care. Among animals, fowls are longer lived than many others, but fiſhes the moſt of all; the latter have the ſmalleſt heart, and the ſloweſt growth, and their bones are never hardened.

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[195] That the change of climate is not always ſufficient to ward off old age, and to prolong life, we find by daily experience; ſeeing ſo many phthiſical and hypochondriac perſons, from every part of the north of Europe, from Britain in particular, betake themſelves to Italy or the ſouth of France, without the hoped for relief. Sulzer is ſtill recent in our memory.

DCCCCLXXII. Death happens ſometimes, but rarely, from mere old age. This we ſay happens when the powers are gradually loſt, firſt of the muſcles ſubject to the will, then of thoſe that are ſubſervient to the vital functions, and laſtly of the heart itſelf; ſo that old men ceaſe to live through mere weakneſs, rather than thro' the oppreſſion of any diſeaſe. I have often obſerved the ſame kind of death in brutes. The heart becomes unable to propel the blood to the extremities, the pulſe and heat deſert the feet and hands; yet the blood continues to be ſent forth from the heart into thoſe arteries that are next to it, and to be carried back from thence: thus the flame of life is ſupported for a little while; which we ſoon perceive to be extinguiſhed, when now the heart itſelf being totally deprived of its powers, and not irritable by the blood to any effectual motion, cannot drive the blood through the lungs, that the aorta may receive its due quantity. Thus the utmoſt force of reſpiration is exerted in order to open a paſſage to the blood through the lungs, until even the powers given by nature for performing the action of inſpiration, become unequal to their taſk, and ceaſe altogether. Thus the left ſide of the heart neither receives blood nor is irritated, and therefore remains at reſt; while yet for a little time the right ventricle, and laſtly the auricle of the ſame ſide, receive the blood brought by the veins from the cold and contracted limbs, and by this means being irritated they continue to beat weakly. But laſtly, when the reſt of the body has become perfectly cold, and the fat itſelf congealed, even this motion ceaſes, and death becomes complete.

DCCCCLXXIII. I would call that death, when the whole irritable nature has left the heart. For the mere reſting of the heart is not without hope of a revival of motion: neither does the putrefaction of any part of the animal body demonſtrate the death of the whole animal; nor does its inſenſibility or coldneſs do ſo: but all theſe things when joined together, and perpetually increaſing, with the ſtiffneſs which follows the coagulation of the fat by reſt and cold, preſent the ſigns of death in any doubtful caſe.

DCCCCLXXIV. The dead body now haſtens to putrefaction. The fat, water, and gluten, in conſequence of ſeparation and diſſolution, conſume: the earth, deprived of its bonds of union, inſenſibly moulders away, and mixes itſelf with the duſt: The ſpirit departs whither God hath deſtined it. By death it is indeſtructible; which is manifeſt from the common and frequent obſervation of phthiſical people, who, while their bodily powers are waſting by diſeaſe, evidently poſſeſs a moſt ſerene, lively, and joyful mind.

INDEX.

INDEX.

CHAP. I. THE FIBRES.

1. THE moſt ſimple parts
2. The common fabric of the ſolids
3. The fibres
Their more permanent particles are earthy
4. The earthy particles cohere by means of a gluten interpoſed betwixt them
5. The gluten is compoſed of oil and water
6. The ſimple fibre
7. A conſpicuous linear fibre
8. Laminæ or plates
9. Common fabric of the cellular texture
Its diverſity in general
10. Membranes formed of the cellar texture
Veſſels
Tunics or coats
11. That the veſſels of the tunics are an acceſſion to the cellular texture
12. That the cellular texture is every where to be found
13. The inorganic concrete
14. That the fibres and cellular texture are formed of the gluten
15. After what manner the ſolids are formed of the gluten.

CHAP. II. THE CELLULAR TEXTURE.

16. The differences of cellular texture
In what parts it is ſhort and tender
17. In what parts it is more lax
18. That the fat is poured out in theſe
19. The ſmall ſanguineous veſſels of the cellular texture
That the fat is depoſited from the extremities of the arteries
That it exudes alſo longitudinally through them
20. That the ſame is reſorbed into the veins
Whether the veins remain in the celular texture
21. That all the cells mutually open into one another
22. The very great dignity or importance of the cellular texture
23. The contractile force of the cellular texture different from the irritable one
24. The various uſes of the fat
25. The cauſes and effects of the fat being collected in the cells, or abſorbed by them.

CHAP. III. THE VESSELS.

26. The figure of the arteries
27. That they have no external and conſtant common membrane
That their firſt true membrane is every where cellular
28. That the exterior one is more lax, and perforated with blood-veſſels and nerves
29. The inner more denſe and proper coat of the artery

30. The muſcular coat formed of circular fibres
That there are no longitudinal ones
A ſhort cellular texture under the muſcular coat
31. The innermoſt membrane of the artery
How this is formed in the arteries of the viſcera
32. The arteries of the arteries
The nerves of the arteries
If there is thence a contractile power diſtinct from the ſimple elaſticity
33. The round light of the arteries
The pulſe of the arteries
34. The ſtrength of the arteries
That the trunk is weakeſt, the branches more ſtrong
35. That the arteries go to all parts
The proportion of the arteries to the parts which they enter
36. The proportion of the ſolid part of the artery to its light or cavity
37. The diviſion of the arteries into branches
The proportion of the light of the branches to that of the trunk
The angles at which the branches go off
The flexions of the arteries
38. The anaſtomoſes and net-works of the veſſels
39. How the ſmalleſt artery goes off into a vein
40. The various diſpoſition of the arteries in the viſcera
41. That the arteries go out into veſſels of the leſſer kinds
42. Otherwiſe they go off into excretory ducts
43. Otherwiſe that they at laſt terminate into exhaling canals
44. Whether every where there are veſſels produced from the red ones
45. Whether the ſmaller veſſels are uſually produced by a multiplied diviſion
46. That the veins belonging to many are ſimilar, to various others are different
47. The ſtructure of the veins
48. The amplitude and diviſion of the veins
That they affect the ſurface of the body
49. The valves of the veins
50. That the origins of the veins are from the arteries, from the veins of the leſſer genera, from the reſorbing veins of the whole circumference, and from every cavity of the body
51. That other veſſels reſorbing from the cellular texture are little different from theſe
52. That there are veins as well as arteries of ſmaller kinds
53. The lymphatic veſſels
54. The conglobate glands
55. Where the lymphatic veſſels are found
That they unite in the thoracic duct
56. The orifice of the conglobate glands
57. The valves of the lymphatics.

CHAP. IV. THE MOTION OF THE BLOOD THROUGH THE ARTERIES AND VEINS, OR THE CIRCULATION.

58. In what manner the blood fills the arteries and veins
59. That the blood moves rapidly through all the veſſels
60.—76. The direction of the motion of the blood
60. Proofs of the communication of the arteries and veins

61. That the blood flows through the arteries from the heart to the extremities
62. That ſome have doubted concerning the motions of the venous blood
Who have acknowledged their error
63. That Harvey firſt ſhowed the venal blood to return from the extremities to the heart
This is proved by the valves which prevent the reflux of the blood into the branches
64. That the valves alſo ſuſtain the weight of the blood
That theſe alſo cauſe the preſſure of the muſcles to drive the blood into the veins towards the heart
65,—70, Which things ſhow the courſe of the venous blood
65. The valves of the right ſide of the heart
66. Ligatures and compreſſion in a living perſon
67. More accurate experiments on living animals
68. Injections into the veins
69. Transfuſion of blood
70. That the blood paſſes from the arteries into the veins, proved by injection
71. That the ſame paſſage is ſhown by the microſcope
That there is no parenchyma between the arteries and veins
72. Which circulation of the blood is proved by what is already ſaid
73. That there are ſome places, however, where the paſſage is for a little contrary to the above mentioned one.
74. That in the lymphatic veſſels the paſſage of the liquor is from their roots to the thoracic duct
75. That all the reſorbed vapours are carried towards the heart
76. That a paſſage muſt be found for the blood from the right ventricle of the heart into the left.

CHAP. V. THE HEART.

77, 78. The bags of the pleura
77. The mediaſtinum
The pleura
78. The place of the pericardium
The hinder part of the mediaſtinum
The ligaments of the lungs
79, 80. The pericardium
81. The arteries of the pericardium
Its veins
Nerves
82. The ſtructure of the pericardium
The water contained in it
83. The uſe of the pericardium
84. What animals have a heart
85. In what manner the vena cava terminates in the heart
86. The right ſinus venoſus
The right auricle
87. The oval foſſa
The oval ring
88. Euſtachius's valve
89. By what powers the blood is forced into the cavities of the heart lying on the right ſide
90. The contraction of the right auricle of the heart, and what follows from thence
91. The figure and ſituation of the heart
92. The anterior or right ventricle of the heart
93. The *valvulæ triglochines*
94. Their papillary muſcles
95. The uſe of the triglochines
96. That the heart is ſtimulated to con-

contraction by the blood forced into it
97. The muſcular fibres of the heart according to the author
98. The ſame deſcribed by others
99. The nerves of the heart
100. That theſe nerves give the heart its power of motion
101. But that there is alſo ſome other cauſe
102. The irritable power placed in the heart
103. How the contraction of the ventricle is performed
104. By the contraction of the heart the return of the blood into the auricle and veins is prevented
105. By the contraction of the right ventricle the blood is driven into the pulmonary artery
106. The origin and beginning of the pulmonary artery
Semilunar Its ~~ſeminal~~ valves
107. The going out of the blood from the right ventricle into the pulmonary artery
108. The paſſage of the blood thro' the lungs
109. That the blood cannot flow back from the pulmonary artery into the heart
110. The pulmonary veins
The courſe of the blood thro' theſe
111. The left ſinus venoſus
The left auricle
112. That the contraction of the left *antrum* forces the blood into the left ventricle
The *valvulæ mitrales*
113. The courſe of the blood from the right ventricle into the left, or the leſſer circulation
114. The left ventricle
115. That the blood is forced into the aorta by the the contraction of the left ventricle
116. The valves of the aorta.
117. The diaſtole of the heart
118. In what manner the motions of the auricles and ventricles alternately follow one another
119. Why theſe motions for ſuch a long time, and ſo conſtantly, follow one another
120. The queſtion anſwered, that this is explained by the ſtimulus of the blood driven into irritable cavities.
121. That nothing elſe is required.
That the reaſon cannot be found either in the compreſſion of the nerves or of the coronary arteries
122. That the powers of the heart are not aſſiſted by the oſcillation of the ſmalleſt veſſels
Nor by the power of external heat
Nor by the contractile force of the arteries
123. The velocity with which the blood iſſues from the heart
The weight of the blood incumbent on the heart
The force of the heart
124. That hence many things are uncertain
That the powers of the heart are notwithſtanding very ſtrong
125. That the ſame is proved by the reſiſtance which the heart overcomes
126. The entrance of the blood into the coronary arteries
The two coronary arteries
127. Their termination in the veins
The great coronary vein
128. The middle vein
The third vein
129. The anterior veins
130. The middle-ſized veins
131. The leaſt veins

132. When the coronary arteries receive the blood
133. That the blood returns from the coronary arteries into the cavities of the heart through the veins.
134. Thr lymphatic veſſels of the heart.

CHAP. VI. THE NATURE OF THE BLOOD AND HUMOURS OF THE HUMAN BODY.

135. The blood in general
136. The warmth of the blood
The vapour iſſuing from blood when drawn
137. That the blood coagulates when this vapour is ſent out from it.
The cruor is the principal part of the coagulum
138. The ſerum of the blood
139. How the blood is changed by putrefaction
140. Beſides theſe, that there are in the blood, ſea-ſalt, earth, earth of iron, and air in an inelaſtic ſtate
141. What changes are wrought upon the blood by the admixture of ſalts
142. The chemical analyſis of the blood
143. A ſummary of thoſe things that are to be known from thence
144. That the red globules are diſtinguiſhed in the blood by the help of the microſcope
Their figure
145. The colour of the globules, their number, magnitude, and figure, variable
Whether or not they break into others ſmaller
146. That fibres are produced from waſhed blood which did not exiſt in the living animal
147. That the cruor is compoſed of globules which are inflammable
148. The chemical analyſis of the ſerum
That the aqueous humours, the ſaliva and mucus, give over the ſame principles by diſtillation
149. The quantity of blood in the whole body
150. That the proportions of the elements of the blood are not always the ſame
Which of them vary in their proportion
151. On the different proportion of the elements, and the conſideration of the ſtructure of the ſolids, depend the differences of conſtitutions
152. The uſe of the red cruor.
153. The coagulable ſerum, thinner liquids, ſaline particles, air, fire; what, and by what means produced
154. That the thick blood and more thin liquids are equally neceſſary for health
155. The difference between the arterial and venous blood.
156. That all the reſt of the humours are produced from the ſame blood.

CHAP. VII. THE COMMON OFFICES OF THE ARTERIES.

157. The blood propelled from the left ventricle into the aorta
158. That the arteries are conſtantly full
The pulſe of the arteries, and its cauſe
159. The contraction of the arteries
160. How it is proved that the artery is contracted, and the blood driven forward by that means
161. That no ſucceſſion can be perceived in the pulſation of different arteries, although we are certain that it muſt actually take place
162. That the velocity of the blood coming from the heart muſt continually be diminiſhed as it proceeds farther through the arteries
What things ſeem to be diminiſhed, without actually being ſo
163. That the blood does not loſe ſo much of its velocity as according to calculation it ought to do
The cauſe of this
164. Why the pulſe vaniſhes in the ſmalleſt arteries
165. That the blood preſſes againſt the ſides of the veins
Why the veins do not beat like the arteries
166. That the pulſe is the meaſure of the powers of the heart
What is meant by a ſlow, large, hard, and quick pulſe
Where it is beſt felt
167. That the pulſe is more ſlow in proportion to the bulk of the animal.
The difference of the pulſe in men according to the time of the day
168. That a frequent pulſe is different from a ſwift one
Different cauſes of a frequent pulſe
169. By what powers the venous blood is moved
170. That the ſame moves more quickly in the trunks than in the branches
171. By what means a ſtagnation tion and coagulation uf the the blood is prevented
172. That the venous blood is propelled by the action of the muſcles
173. Other powers compreſſing the veins
174. The power of derivation
What are the uſes of the anaſtomoſes
175. The velocity of the venous blood
What cauſes render its motion more difficult
176. The time in which the circulation is performed
177. The effects of the motion of the heart and arteries on the blood, by what means they are calculated
178, 179. By what means we underſtand the manner in which theſe things are carried on
180. What friction takes place in the arteries.
Its effects how calculated
Whence the redneſs of the blood
181. Whether heat is produced by the motion of blood
182. That the progreſſive motion of the blood hinders putrefaction
183. That it is various in different particles of a different diſpoſition

184. The effects of the ſyſtoles of the arteries
185. That the ſmalleſt mouths of the arteries are modles in which the ſmall maſſes of blood are formed
186. What is the uſe of the reticular works of the arteries
187. The effects of a ſlow motion of the blood.

Chap. VIII. Of SECRETION.

188. Four claſſes of ſecreted humours
That the firſt is of the coagulable ones, which for the moſt part exhale
189. That the ſecond is of ſuch as are not coagulable, which partly exhale, and partly not
190. That the third is of the mucous ones
191. That the fourth is of the inflammable ones
192. That the other humours are compoſed of theſe
193. That a deſcription of the ſecretory organs is required, according to what we obſerve of the different natures of the humours ſecreted by different organs
194. That the ſecretion of coagulable liquors is performed without glands
195. What glands ſecrete the albuminous humour of the joints
196. The ſeat of theſe glands
197. That the exhaling liquors which are not coagulable are ſecreted without glands
198. That ſuch liquors as are neither coagulable nor exhaling, are ſecreted by conglomerate glands
That theſe are made up of kernels
199, 200, 201. The ſtructure of theſe kernels
202. That the liquors of 198 are even ſecreted without theſe kernelly glands
203. That the mucus is every where ſecreted by glands
The ſtructure of a true gland
204. How the ſecretion is performed in theſe glands
205. The mouth of the excretories
The *cryptæ* or cells
206. The conglutinated glandules
207. The excretory ducts
208. The compound glands
The *agminated* or congregate glands
209. The various ſecretion of inflammable liquors
That there are many ſebaceous glands without a duct
That there are other ſebaceous ones which have a duct
211. Compound ſebaceous ones
212. That milk is ſecreted in the conglomerate glands
213. The organs being deſcribed, that we muſt return to the queſtion 193.
214. That the blood coming to the ſecretories is of a particular nature
215. That the retardation of the blood in the leaſt veſſels ſeparates the more denſe humours from the lighter and ſuch as are more ſlow in their motion
216. That the mouths of the ſecretory veſſels are of different diameters
217. That this inequality may alter the ſecreted humours in many different ways
218. That moſt ſecretions happen

through ſmall veſſels riſing from a red artery
That ſome, however, are made by theſe veſſels which ariſe from others of a leſſer kind
219. That perhaps the angle at which the ſecretory branch goes off is of ſome conſequence
What things render this probable
What things render it doubtful
220. That the flexions of veſſels contribute to ſecretion
221. That the thickneſs of the arteries may do the ſame
That their irritability does almoſt the ſame things
222. That various things which augment or diminiſh the velocity of the blood have great effect on the ſecretions
223. That the ſecreted humours vary by a variation of theſe conditions
224. That the moſt large and denſe particles of the blood paſs into the veins
225. What becomes of the large, ſlow, and ſluggiſh particles
And of the coagulable ones
226. In what veſſels the thin and aqueous liquors are ſecreted
226. * In what veſſels are ſecreted the light aqueous but viſcid and ſlow humours
227. Various hypotheſes are formed concerning ſecretion
228. It remains to be found out how the pure ſecretions are made
That all humours newly ſecreted have an admixture of water
229. What humours become viſcid by ſtagnating in the veſſels
230. That liquors may be changed in their receptacle by the admixture of a new liquid
231. That the reſorbed humours are alſo of uſe
232. The uſe of receptacles
233. The powers by which the retained humours are at laſt ejected.

CHAP. IX. OF RESPIRATION.

234. The figure of the lungs
235. The external membrane of the lungs
236. The ſtructure of the lungs
337. The ſtructure of the aſpera arteria
238. The fibres of it are muſcular
239. Its mucous glandules
The conglobate glands in their neighbourhood
240. The veſſels and nerves of the aſpera arteria
241. Its diviſion into bronchia
242. That their ultimate branches terminate in the cellular texture
243. The bronchial arteries and veins
244. The pulmonary artery
245. The pulmonary veins
245. *The lymphatic veſſels of the lungs
The nerves of the lungs
246. That a very large portion of the blood enters the lungs
That the utility of this viſcus depends on the air
247. The nature of atmoſpherical air
248. In what manner it is excluded from the body
It ought to be underſtood why it enters the lungs
249. It is ſhown why it enters them
250. The general fabric of the thorax

251. The

251. The vertebræ of the back
252. The articulation of the ribs with the vertebræ
The ligamenrs of the latter
253. How the ribs are joined with the ſternum
254. The length of the ribs.
255. The direction of the ribs
Their ſtrength various
256. The ſternum
257. That the thorax muſt be raiſed in order to dilate the ſeat of the lungs
That this is performed by the external intercoſtal muſcles.
358. The internal intercoſtals.
There are doubts concerning the action of theſe, but it is certain that they are elevated
259. By what means theſe enlarge the thorax. They are not, howeyer, ſufficient to perform this dilatation
260, 261. The diaphragm
262. The two holes of the ſeptum
263. That the contraction of the ſeptum augments the capacity of the thorax
But that this is performed only by means of reſpiration
264. What powers conſpire to produce the more deep inſpirations
265. Inſpiration how performed
Its effects on the air and blood-veſſels
266. Whether there is air between the lungs and thorax
267. That the air is vitiated by reſpiration
268. The inconveniences of too long an inſpiration
269. The powers of exſpiration
270. That the abdominal muſcles conſpire to produce this effect
That the ſternocoſtals and others alſo aſſiſt
271. What powers aſſiſt the muſcles in the ſtronger reſpirations
272. The effects of exſpiration
273. That from thence there ariſes a new neceſſity for reſpiration
274. That we can ſcarce aſſign any other cauſes for alternate reſpiration
275. That reſpiration is neceſſary for an adult
276. That the uſefulneſs of reſpiration is different from that neceſſity
277. From whence theſe things are diſcovered
278. Whether animal-heat is generated in the lungs
279. Whether the blood is condenſed in the lungs
280. Whether air itſelf is received into the blood in the lungs
What things render this probable
281. What things ſeem to prove the contrary
282. Whether the blood is cooled in the lungs
283. Whether the red colour of the blood proceeds from the air
285. Whether the uſe of the blood is to abſorb nitre from the air
286. What animals live long without air
Why every animal dies in air that is not often changed
287. What is the agreement between the pulſe and reſpiration
288. Cough
289. Laughter
Weeping
Hickup
Sneezing
290. The acceſſory uſes of reſpiration.

CHAP. X. [XI.] THE VOICE AND SPEECH.

291. That the larynx is made of cartilages
Its veſſels and nerves
292. The ſcutiform cartilage
293. The annular cartilage
294. The arytenoide cartilages
295. The glottis
296. The epiglottis
297. The ventricles of the larynx
298. The mucous glandules of the larynx
299. The thyreoide glandule
300. The connexion of the larynx with the os hyoides
The elevation and narrowing of the larynx and glottis
301. The depreſſion and dilatation of the larynx and glottis
302. The cavity of the mouth
The noſtrils
303. The tongue
304. The voice
Whiſpering
305. The ſtrength of the voice
How an acute tone is made
306. That a grave tone is produced by oppoſite cauſes
307. The cauſes of a diverſity of tones
308. Singing
309. Speech
310. The pronunciation of letters.

CHAP. XI. THE BRAIN AND NERVES.

311. A conſideration of the order
312,—319. The arteries which belong to the brain
312. The arch of the aorta, and the branches produced from it
313. The diviſion of the carotid
The external carotid. From it proceeds
The ſuperior thyreoide artery
The lingual artery
The labial one
The aſcending pharyngea
314. The occipital artery
The auricular one
315. The temporal artery
The internal maxillary one
316. The principal branch to the dura mater
Other branches of the internal maxillary
316. *The internal carotid
Its angles
Its paſſage through the foramen of the os petroſum
The branches produced from it in the receptacle
317. The branches of the internal carotid on the bridge and crura of the brain
The branch accompanying the plexus choroides and optic nerve
The anterior and poſterior branch
The ſtructure of the branches of the carotid artery which lie within the ſkull
318. What may be collected from the hiſtory of the arteries of the brain
320. 324. The coverings of the brain
320. The bony covering of the encephalon
The hard membranes in general
321. The external and internal lamina of the hard membrane
The falx and tentoria proceed from theſe, and what is their uſe
322. The glands
323. The arachnoid membrane
324. The pia mater
325. 339. The veins of the encephalon
325. The fourth ſinus

326. The ſuperior ſinus of the falx
The tranſverſe ſinuſes
327. The inferior ſinus of the falx
328. The inferior, anterior, and poſterior veins of the brain
329. The veins of the cerebellum
That the ſuperior ones terminate in the fourth ſinus; the inferior ones in the ſuperior and tranſverſe ſinus of the os petroſum
330. A ſinus like a circle
The tranſverſe ſinuſes joining the cavernous ones
331. The ſuperior ſinus petroſus
The inferior ſinus petroſus
The poſterior occipital ſinus
332. The anterior occipital ſinus
The cavernous ſinus
The conjunction of the ſinuſes and external veins of the cranium with one another, and what happens from thence
333. The uſe of the ſinuſes
334. What happens to the arteries with the ſinuſes
335. That the blood chiefly flows into the jugular veins
Their cerebral and facial branches
336. The external jugular vein
The internal vertebral vein
337. The ſinus of the medulla ſpinalis
338. The uſes of the venal anaſtomoſes
339. The lymphatic veſſels of the brain
The reſorption of that which exhales in the brain
340. That a great number of parts are comprehended under the name of *encephalon*
The cerebrum, cerebellum, bridge, and medulla oblongata, what they are
341. The figure of the brain
Its *gyri* or circumvolutions
Its cortex
Medulla
Lobes
342. The more ſubtile ſtructure of the brain
343. 53. The interior anatomy of the brain
343. The oval ſection of the brain
The corpus calloſum
344. The anterior or three-horned ventricle
345. The corpora ſtriata
The thalami of the optic nerves
The double ſemicircular centre
The anterior commiſſure
The mamillary eminences
346. The pellucid ſeptum
The fornix
The fimbriæ
The hippocampi
The pſalterium
347. The choroid plexus
348. The third ventricle
349. The pituitary gland
350. The poſterior double commiſſure
351. The ſeparation of the third ventricle from the calamus ſcriptorius
The anterior commiſſure
352. The nates
The teſtes
The pineal gland
353. The crura of the brain
354. The cerebellum
355. The bridge
The medulla oblongata
The olive-ſhaped and pyramidal bodies
The fourth ventricle
The great valve
The aqueduct
The calamus
356. The common origins of the nerves of the brain
357. The origins of each of the ſingle nerves of the brain
358. The medulla ſpinalis
The pia mater, arteries, and veins of the ſame
359. The arachnoid membrane of the medulla ſpinalis

360. The

360. The hard membrane of the medulla ſpinalis
The toothed ligament
361. The common properties of the ſpinal nerves
362. The anterior and poſterior trunks of the ſpinal nerves
The intercoſtal nerve
The eighth pair
The phrenic nerve
The acceſſory nerve
364. The extremity of the nerves
The ſtraightneſs of the fibres of the nerves
That the nerves are ſcarcely elaſtic, and not at all irritable
The number of nerves in proportion to the parts to which they are ſent
The anaſtomoſes of the nerves
Ganglions
365. How it is proved that ſenſation is owing to the nerves
That it is the medullary part of the nerve which feels
366. That the ſoul perceives in the brain, not immediately by the ſenſoria and branches of the nerves
367. How the muſcles are affected by compreſſing or irritating the nerves
368. What impediments of the animal motions happen on hurting the brain or ſpinal marrow
369. From what is laid down in 367 and 368, the nerves are proved likewiſe to be the organs of motion
370. Whether there is in the brain any principal ſeat in which is the origin of all motions, and the end of all ſenſation, where the ſoul reſides
That that ſeat is not in the corpus calloſum
371. Nor is it the proper province of the cerebellum to carry on the vital motions
Nor are we to derive the motions called *animal* and *vital* from different ſources
372. That the ſeat of the ſoul is where the nerves firſt begin
373. That the nerves are the organs of ſenſation and motion, not by their membranes, but their medullary part
374. What the medulla is
375. Whether a medullary fibre is ſolid
376. That the nerves are entirely devoid of elaſticity
377. That motion can only be propagated downwards
That from what is already ſaid, it follows, that the medullary fibre ſeems to be hollow
378. A diſproof of the objections uſually brought againſt this
379. The nature of the nervous fluid
How proved not to be electrical
380. That the nature of that fluid is neither aqueous nor albuminous
381. Of what kind the nervous fluid ought to be
382. How it is rendered more probable that the nervous fluid paſſes through a hollow tube than through a ſpongy ſolid
383. A double motion of the nervous juice
384. That the ſame nerves moſt evidently ſerve both for ſenſe and motion
385. What becomes of the nervous fluid
Whether it nouriſhes the body
386. Queſtions concerning the uſes of the different parts of the brain
387. The offices of the ventricles
388. What is known concerning the uſe of the tubercles
389. The offices of the ſtriæ and the internal ducts
390. The order of thoſe things which follow conſidered.

CHAP. XII. MUSCULAR MOTION.

391. What is called the dead power of the fibre
392. The reaſon why it is called *dead*
Its effects
393. The power of the dead fibre commonly known.
The properties of the common red muſcular fibre
394. What the fibres of a muſcle, and the muſcle itſelf, are
395. The fibres treated more fully
396. The belly, tendon, aponeuroſis, and capſule of a muſcle, what
Whether the fibres of the tendons are of a different genus from the muſcular ones
The parts in which the muſcles go off in long tendons, and thoſe to which they affix themſelves
397. The reaſons of the tendons uniting themſelves with the fleſh
A pennated muſcle, what
398. The arteries, veins, lymphatics, and nerves, of the muſcles
399. The ſtructure of the leaſt fibre which ſerves as an element to the muſcle
400. That there is a threefold force in the muſcle
The *vis inſita* of the muſcle
401. The meaſure of the muſcles ſhortening when they contract
402. Other things which relate to the *vis inſita*
403. The nervous power of the muſcle
404. In what the nervous power and *vis inſita* differ
405. The phenomena in the motion of the muſcles ariſing from the nervous power and *vis inſita*
406. What the arteries contribute to the motion of the muſcles
407. A refutation of the cauſes by which the nerves are ſaid to move the muſcles
408. That the nervous fluid ſeems to ſerve in the place of a ſtimulus; and that its moving cauſe is not the ſoul, but a law derived from God
409. What things ſhow that in the motion ariſing from the *vis inſita*, the ſoul does not interfere
410. What things happen to the muſcles obeying the will, and to thoſe which are governed by a *vis inſita*
411. The magnitude and loſs of the powers which the muſcles exert in their contractions
412. The proportion of theſe loſſes
313. What thoſe that are called antagoniſts contribute to the motion of the muſcles
414. Other helps to this motion
416. The co-operation of the muſcles
417. What effects are produced by the action of the muſcles
418. The relaxation of a ſtretched muſcle
What becomes of the ſpirit ſent out from the brain.

CHAP. XIII. TOUCH OR FEELING.

419. What feeling is
A conſideration of the order
420. Touch in general
421. Touch in another and more proper ſenſe
422. The true ſkin
423. The granules and papillæ of the ſkin
424. The epidermis
425. The rete Malpighianum
426. Of what the net-work and epidermis are made
427. The glands of the ſkin
That there is another ſpring of oily liquor, and what it is
428. The hairs
429. The nails
430. That the ſubcutaneous cellular texture in very few places is free of fat
What purpoſe it ſerves after it has received the fat
That the ſkin and Malpighian mucus, where they ſeem perforated, are drawn inward and degenerate
431. The reaſon of feeling, and the qualities which are known from thence
432. The Malpighian mucus, hairs and nails, what purpoſe they ſerve
433. A vapour perſpires through an infinite number of little arteries of the ſkin
434. The ways of demonſtrating this exhalation
435. Sweat
436. The elements of perſpiration
Water
The odours of aliments
The electric matter
437. Another volatile element of perſpiration, ſomething of an alkaline nature
438. The quantity of perſpiring liquid
439. Of what uſe the quantity of perſpiring liquid is
What things augment or diminiſh it, and what follows from thence
440. How ſweat benefits or hurts the body
441. The uſe of perſpiration
442. Inhalation, by what arguments it is proved
443. How it is proved that both the exhaling and inhaling veſſels may be contracted and relaxed by the power of the nerves.

CHAP. XIV. TASTE.

444. That taſte is chiefly exerciſed by the tongue
445. The tongue in general
Firſt kind of its papillæ
446. The fungiform papillæ
The conical ones
Others which intervene
447. The nerves of the tongue
448. The arterious and nervous villi which run between them
449. The covering of the tongue
450. The muſcles of the tongue
451. The veſſels of the tongue
452. The manner of exerciſing the taſte
Flavours, and their cauſe
453. What things contribute to the perception of taſtes
454. That the ſpirits are reſumed either into the papillæ or the abſorbing villi of the tongue
455. The uſe of the ſenſe of taſte.

CHAP. XV. OF SMELL.

456. The uſe of ſmell
457. That ſmell is exerciſed by the help of the membrane of the noſtrils
The nerves of that membrane
458. The arteries, membranes, and veins of the noſtrils
459. What the noſtrils are
The ſeptum of the noſtrils
560. The uppermoſt, middle, and loweſt oſſa ſpongioſa
461. The ſinuſes in general, what they are
The frontal ſinuſes
462. The ethmoidal ſinuſes
The ſinus of the multiform bone
463. The ſinus of the maxillary bone
464. The mucus of the noſtrils
The ſinuſes abounding in mucus can evacuate it in any ſituation of the body
465. The noſe and its muſcles
466. The manner of exerciſing the ſenſe of ſmell
In what things it agrees or diſagrees with the ſenſe of taſte
467. The ſtrength of odours
The parts of the noſtrils which primarily belong to the ſenſe of ſmelling.

CHAP. XVI. THE HEARING.

468. The reaſon of the difference between the organ of hearing and that of the other ſenſes
469. The lap of the ear and its parts
470. The glandules and muſcles of the lap of the ear
471. The meatus auditorius
472. The ſkin and cuticle of the meatus
The glandules for ſeparating its wax, and the wax itſelf
473.477. Air, according to the natural philoſophers
474. Tones
475. The velocity of ſounds
476. Sympathetic tremors
The ſtrength of ſound
Echo
477. How ſound rebounds from hard bodies
The reaſons of the increaſe and weakneſs of ſounds
478. The collection of ſounds in the meatus auditorius
479. The membrane of the tympanum
That the ſounds ſtrike upon it after their ultimate reflexion in the meatus auditorius
480. The tympanum
481. That the four little bones which perform the office of hearing are placed in the tympanum
The malleus
482. The muſcles of the malleus
The effects of a ruptured membrane of the tympanum
483. The incus
484. The ſtapes and its muſcle
485. The little round bone
486. The various canals go out of the cavity of the tympanum
A certain appendix to the tympanum, of the figure of a gnomon
Small cells above the mamillary proceſs, and in the proceſs itſelf
487. The tube
488. That two other paſſages lead from the tympanum into the labyrinth
The oval feneſtra
The veſtibulum

489. The ſemicircular canals
490. The round feneſtra
The cochlea
491. The veſſels of the organ of hearing
492. The nerves belonging to this organ remain to be deſcribed
The ſeventh pair of nerves, and its hard portion
The nerves of the lap of the ear
493. The ſoft branch of the ſeventh pair of nerves
494, 5. Various things concerning the ſeat of hearing
496. What things are more certainly underſtood concerning this matter
497. The diſtinction and gratefulneſs of ſound.

Chap. XVII. SIGHT.

498. The difference between ſight and hearing
That the organ of ſight is neceſſarily compounded
499. The eye-brow
500. The palpebræ
The conjunctiva
The nerves and arteries of the palpebræ
501. The tarſus
The levator muſcle of the ſuperior palpebra
The orbicularis palpebrarum
502. The cilia
503. The Meibomian ſebaceous glands
504. The tears and their fountains
505. The duct of the lacrymal glands
The effects of the contraction of the orbicular muſcle
506. What becomes of the tears
The caruncula lacrymalis
The third palpebra
The punctum lacrymale
507. The ductus lacrymalis
The lacrymal ſac
The naſal duct
508. The figure of the eye
The orbit
The fat poured out around it
509. The optic nerve
Its progreſs
510. What afterwards becomes of that which touches the eye
511. The ſclerotica
The cornea
512. The choroides
The Ruyſchian lamina
The ciliary circle
The pupil
The iris
The uvea
The membrane covering the pupil in the fœtus
513. The motion of the iris
514. The ciliary ligaments
515. The retina
516. The humours of the eye
The vitreous humour
517. The cryſtalline lens
518. The aqueous humour
The arches of the eye
519. The ſtraight muſcles of the eye
520. The oblique muſcles of the eye
521, 522. The nerves of the eye
521. The ophthalmic branch of the fifth pair
522. The branches of the third pair
523. The motion of the ciliary proceſſes
524, 527. The arteries of the eye
528. The veins of the eye
529. Light in general
530. That light conſiſts of rays ſhowing different colours
531. The colours proper to every body, whence they come
Opake bodies what

532. How refraction happens, and what it is
533. When rays fall on a convex ſpheric body, which of them are refracted, and which reflected
    The focus of the refracted ones
534. What rays falling upon the cornea are reflected, or being refracted are ſuffocated or come to the lens
535. How the rays are refracted in their paſſage through the cornea and aqueous humour
536. How they are refracted by the cryſtalline humour
538. How they are refracted by the vitreous humour, and are at laſt collected upon the retina
539. Whether objects are rather painted on the choroides
540, 541. How the eye is thought to accommodate itſelf to the various diſtances of objects
542. But that nothing of this kind happens
543. Myopia
544. The cure of this diſorder
545. Preſbyopia
546. The remedy for preſbyopia
547. That a medium between ſhort and long ſightedneſs is beſt
548. In what manner we judge of the magnitude of objects
549. The force of the light and its effects
550. How the place of an object is eſtimated
551. Diſtance
552. How we perceive gibbous objects
553. In what manner we judge of the ſituation of the parts of objects
554. That the images of objects remain for a little time, even after the objects themſelves are removed
555. Various queſtions concerning viſion.

CHAP. XVIII. INTERNAL SENSES.

556. That ſenſation then happens when a new thought ariſes in the mind by the percuſſion of a nerve
    That that thought is not the image of the object affecting the nerve
    That thence an arbitrary connexion ariſes between the changes produced in the nerves and the thoughts produced in the mind
    Why, notwithſtanding this, what we perceive of this world is not falſe
557. What things are joined together while we think
558. That the changes produced by objects in the nerves remain a long time in their origin
    The preſervation and order of theſe traces
559. Imagination, what it is
560. Memory
561. At what times of life the memory and imagination flouriſh, and when they decay
562. Thought and attention
    Judgment and genius
    The ſprings of error
563. Soundneſs of judgment, on what it depends, and by what it is weakened
564. What ideas moſtly affect the will
565. The affections of the mind
    Effects of the affections of the mind
566. The cauſes of theſe effects
567. That the paſſions of the mind are faithfully expreſſed in the countenance

Phyſiognomy, whence it ariſes
568. Conſent of parts, whence it ariſes
569. That the nature of the ſoul is different from the body
570. That the ſoul, however, is moſt cloſely connected with the body
571. That we have no occaſion to be aſhamed of our ignorance of the reaſon of this connexion
572. By what arguments chiefly thoſe are perſuaded who ſeek for the origin of all the motions and actions in the body from the ſoul
573. 576. Objections againſt that opinion
577. Watching
Sleep
578. Dreams
That with theſe, ſome voluntary motions are ſometimes conjoined
579. What actions continue to be carried on during ſleep
580 How the mechanical cauſe of ſleep is to be diſcovered
The phenomena of watching and ſleep
581. 584. What things contribute to ſleep, and what produce it
585. The proximate cauſe of ſleep
586. 587. That this is confirmed by the cauſes of watching, and what theſe cauſes are
588. That the ſeat of ſleep is not in the ventricles of the brain
Why the vital actions go on in the time of ſleep
589. The effects of ſleep
590. Various queſtions concerning the nature of ſleep.

CHAP. XIX. MANDUCATION, SALIVA, AND DEGLUTITION.

591. That moſt kinds of food ſtand in need of manducation
592. That therefore moſt animals are furniſhed with teeth
Their ſtructure in general
593. That mankind, on account of their diverſity of food, have different kinds of teeth
The inciſors
594. The canine teeth
595. The grinders
596. That the teeth are fixed in the jaw-bones
The various motions and articulation of the lower jaw
597. The levators of the jaw
The pterygoideus externus
598. How the jaw is depreſſed
599. The powers of the levator muſcles
The muſcles producing a lateral and circular motion of the jaw
600. The cheeks
The lips
The mouth
The ſituation and mobility of the tongue in the mouth
601. The liquor poured upon the aliments during maſtication
Its fountains
That the ductus inciſivus is blind
602. The ſaliva
603. The parotid gland
The gland called the acceſſory one
604. The maxillary one
The ſublingual one
605. That theſe, when compreſſed, pour out their liquor during the time of maſtication
Which compreſſion only produces the appetite
606. That the aliments are triturated with ſaliva and air during

ring the time of feeding
That thus they are rendered ſapid
That the volatile parts are thus reſorbed
607. The motion of the tongue for revolving the aliment from one part of the cavity of the mouth to another
608. That the tongue is directed by the os hyoides
The muſcles depreſſing the os hyoides
609. The muſcles raiſing the os hyoides
610. The muſcles of the cheeks and lips
611. The aliment being chewed is then collected by the tongue, and protruded towards the fauces
612. How the food is carried from the mouth into the fauces
How the entry into the larynx is cloſed
613. The pharynx
614. The muſcles dilating the pharynx
615. How we take care that no food falls into the larynx
The velum of the palate
The uvula
616. How the return of the aliment into the mouth is prevented
How the epiglottis and uvula are erected after they have been depreſſed
617. The powers which preſs the aliments downward by the pharynx
The action of the arytenoid muſcles
618. The mucus of the pharynx, and the various ſprings of it
619. The tonſils
The mucus of them exceedingly ropy
That the neighbouring parts are full of mucous organs
The more fluid mucus of the œſophagus
The veſſels of the tonſils, pharynx and œſophagus
619 *The œſophagus
620. The paſſage of the aliment through the œſophagus
621. The contraction of the upper orifice of the ſtomach

CHAP. XX. THE ACTION OF THE STOMACH ON THE ALIMENTS.

622. The ſituation, figure, and bigneſs of the ſtomach
623. The viſcera in the neighbourhood of the ſtomach
624. The external membrane of the ſtomach
The firſt cellular coat
625. The muſcular coat of the ſtomach
The ligaments of the pylorus
626. Another cellular coat
The nervous coat of the ſtomach
The third cellular coat
The villous coat
The valve of the pylorus
The pores of the villous coat
627. The arteries of the ſtomach
628. The diſtribution of the arteries through the coats of the ſtomach
629. The veins of the ſtomach
630. The nerves of the ſtomach
631. The lymphatic veſſels of the ſtomach
632. The inorganic pores of it
633. A mucus anointing the villous membrane
The limpid humour which the arteries diſtil

634. The preſſure of the diaphragm and muſcles of the abdomen on the ſtomach
635. The neceſſity of meat and drink
636. The phenomena of hunger
637. New chyle, the uſe of it
638. The cauſe of hunger
639. The ſeat of thirſt
How it is excited
How quenched
640. The pleaſure of taking food
641. That we ought to inquire why a diet is required conſiſting of two kinds of aliments
642. Why fleſh is required
643. Why vegetables
644. Drink
645. Pickles and ſauces
646. Preparations of aliments
647. The meaſure of food
648. The changes which happen to the food in the ſtomach
649. What hinders the food from degenerating into a full acidity in the ſtomach
That there is no kind of ferment here
650. The periſtaltic motion of the ſtomach driving the aliment into the inteſtines
651. The more powerful force of the diaphragm and abdominal muſcles
In what order and time the aliments go out of the ſtomach
652. What portion of drink in the ſtomach is abſorbed into the veins
653. Vomiting
654. A conſideration of the order.

CHAP. XXI. THE OMENTUM.

655. The peritonæum and its circuit
656. That the cellular texture placed round the peritonæum is continued into the capſules
Its communications with other parts
657. The productions and ligaments of the peritonæum
By the ſeparated laminæ of the peritonæum the viſcera are ſurrounded, and kept firm and defended in motions and concuſſions of the body
658. 659. The meſocolon
660. That the meſocolon and meſentery are hollow
The ſlender purſes of the meſocolon
661. The meſentery
662. What things are found in all parts of the meſentery and meſocolon
663. That many parts come under the name of *omentum*
Their nature in general
A membrane coming from the external membrane of the colon, and loſing itſelf in the fiſſure of the liver
The natural mouth, and common gate of the omenta
664. The leſſer hepatico-gaſtric omentum
665. The anterior lamina of the greater gaſtro-colic omentum
666. The poſterior lamina of the ſame
667. The omentum colicum
668. That it is common both to the omentum and meſentery to preſerve the fat
How it is proved that this fat is received into the veins
669. The arteries of the omenta
670. The nerves of the omenta
671. The arteries of the meſentery and meſocolon
672. The veins of the omentum and meſentery

The

The lymphatic veſſels of the omentum
673. Other uſes of the omentum
674. The uſe of the meſentery
675. The water reſorbed by the veins of the meſentery, what ſort it is, and what it contributes to the bile.

CHAP. XXII. THE SPLEEN.

676. The ſubſtance of the ſpleen
Its figure
Connection
Its ſituation, bulk, and number
677. The arteries and veins of the ſpleen
678. The lymphatic veſſels of the ſpleen
679. Its nerves
680. Its internal ſtructure
The ſurrounding membrane
681. That the ſpleen contains a great deal of blood
Its nature
682, 683. The uſe of the ſpleen
684. Conjectures concerning it.

CHAP. XXIII. THE PANCREAS.

685. The pancreatic juice
686. The ſituation and figure of the pancreas
Its ſtructure
Its veſſels
Its nerves
687. The pancreatic duct
688. The quantity of pancreatic liquor
The powers by which it is expelled
The perpetuity of the pancreas is an argument of its utility
Whence the effervescence with the bile is produced
688. *The utility of the pancreatic juice.

CHAP. XXIV. THE LIVER, GALL-BLADDER, AND BILE.

689. The bulk of the liver
The ſituation of the liver by reaſon of the diaphragm
The ligaments from it
Other ligaments
How it can be moved
Its common membrane
690. How the liver is ſituated with reſpect to the colon, kidneys, duodenum, ſtomach, and pancreas
691. The ſhape of the liver
692. The furrows of the liver
Its lobes
693. The arteries of the liver
694. The umbilical vein
The ductus venoſus
695. The large trunks of the vena portarum
696. The capſule of the vena portarum
The diviſions of the branches
That theſe branches perpetually accompany the hepatic artery
The proportion of the branches of the vena portarum to its trunk
697. The branches of the cava
The proportions of its branches to thoſe of the vena portarum
The trunk of the vena cava
The ſmaller veins creeping

over the ſurface of the liver
698. The paſſage of the blood thro' the vena portarum
699. The nerves of the liver
700. The lymphatic veſſels of the liver
701. 3. The internal ſtructure of the liver
704. How it happens that the bile is not ſecreted from the hepatic artery, but from the vena portarum
705. How the ſecreted bile is driven into the biliary ducts and through them
706. The ſtructure of the biliary duct
Its irritability and ſenſation
707. The ductus choledochus
708. The ductus cyſticus
The gall-bladder
Its ſituation
709. The ſhape of the gall-bladder
The wrinkles of the ductus cyſticus
710. The coats and muciferous pores of the gall-bladder
The exhalation of the arteries into the bladder
That the bile exſudes through inorganic pores
711. That in man, no ducts come from the liver into the gall-bladder
711. *That the bile flows into the inteſtine both from the liver and from the gall-bladder
That all the bile is not firſt conveyed to the gall-bladder
The quantity of bile
How often the bile flows into the bladder
That the bile is not ſecreted by its proper veſicle
712. The return of vitiated bile into the blood
713. The change which the bile undergoes in the cyſtis
That it returns to the gall-bladder, when there is no uſe for it in the inteſtines
714 The powers which expreſs the bile from the gall-bladder
715. The qualities, elements, and offices of the bile
716. Where the bile goes off
That it ſometimes comes into the ſtomach
The coagulation and uſe of the bile in the fœtus
717. The proper uſe of the liver in the fœtus

CHAP. XXV. THE SMALL INTESTINES.

718. The ſmall inteſtines in general
Their diviſion
719. The duodenum
That in it chiefly the bile and pancrearic juice are mixed with the aliments
720. The ſeat of the remaining part of the ſmall inteſtines in general
721, 27. The ſtructure of the ſmall inteſtines
721. The external coat
The firſt cellular one
722. The muſcular coat
723. Another cellular coat
The nervous coat
The third cellular coat
The villous coat
Its folds
724. The villi of the inteſtines
725. The veſicles of the villi
726. The larger pores of the villous coat leading to the mucous glands
727. The leſſer pores likewiſe depoſiting mucus
728. 730. The arteries of the ſmall inteſtines

730. The

730. The arteries of the duodenum
731. The veins of the ſmall inteſtines
How it is proved that theſe abſorb a thin humour from the inteſtines
732. The nerves of the ſmall inteſtines
733. A liquid flowing from the arteries into the cavity of the inteſtine
Its quantity
The uſes of the mucus of the ſmall inteſtines
734, 5. The periſtaltic motion
736. The changes which the food undergoes in the ſmall inteſtines
737. The office of the ſmall inteſtines in general
738. The principal cauſes which change the aliments in the ſmall inteſtines

Chap. XXVI. The LARGE INTESTINES.

739. The remains of the food after the chyle is extracted
740. How the ileon moves itſelf towards the colon
The valve of the colon
741. The blind extremity of the colon
The appendix
The change of ſtructure which happens to the cæcum in an adult from what it is in the fœtus
That the fetor of the excrements begins chiefly there
742. The ſituation and connections of the inteſtinum colon
743. The ſtructure of the colon in general
Its ligaments
744. The cells of the colon
The wrinkles, follicles, and pores of its villous membrane
745. The veſſels of the large inteſtine
746. The diviſion of the veſſels to the large inteſtines
The exhalation and reſorption from theſe
The hemorrhoids
747. The lymphatic veſſels of the large inteſtine
That chyle is ſometimes obſerved in theſe
748. The nerves of the large inteſtine
749. The feces of the inteſtinum colon
The periſtaltic and anti-periſtaltic motion of the colon
Flatus
750. How the ileon is ſhut up
The paſſage of the feces thro' the colon
751. The ſituation and duct of the rectum
752. The external and muſcular coat of the rectum
753. The internal ſphincter of the anus
The villous coat of the rectum
Its folds, and mucous glandules
The ſebaceous glandules of the anus
754. The external ſphincter of the anus, and its action
How the anus is naturally contracted
755. The levator muſcles of the anus
756. The excretion of the feces
757. The feces themſelves.

CHAP. XXVII. THE CHYLIFEROUS VESSELS.

758. The nature of the chyle.
759. The abſorption of the chyle, and its paſſage through the lacteal veſſels
In what animals lacteal veſſels are found
How they are diſpoſed in the different inteſtines
760. The valves of the lacteals
The cauſes of the chyle's motion through the coats of the inteſtines
761. The glands of the meſentery
That the chyle goes from the inteſtines to theſe glands
762. What happens to the chyle in the glands of the meſentery
763. The paſſage of the lacteals from the meſenteric glands to the receptacle of the chyle
764. How the paſſage into the receptacle of the chyle is demonſtrated
765, 6. The thoracic duct
767. That the chyle comes into the blood through the thoracic duct
568. The cauſe of the motion of the chyle in general
769. The change of the chyle during its circulation with the blood
That in the inteſtines there are not lacteal and lymphatic veſſels of different kinds
770. That the lymphatic veſſels abſorb water after the time of digeſtion is expired
That the thoracic duct brings back the lymph of the whole body.

CHAP. XXVIII. THE KIDNEYS, BLADDER, AND URINE.

771. That a part of the water brought into the blood by the chyle is ſtrained through the kidneys
772. The ſituation and connexion of the kidneys
Their figure
External membrane
Their fat
Ligaments
773. The arteries of the kidneys
774. The veins of the kidneys
The quick paſſage of the blood from the arteries into the veins
The veins of the renal fat
775. The lymphatic veins of the kidneys
776. The nerves of the kidneys
777. The renal capſule
778. 80. The internal ſtructure of the kidney
778. The ſtructure of the cortical part
The uriniferous veſſels
The glandules
779. The papillæ of the kidneys
780. The infundibula, or funnels
The pelvis
781. The ſecretion of the urine
The quantity of the urine
782. The elements of the urine
783. How the ureter moves the urine forward
The ureter itſelf
784. How it is proved that the urine is ſeparated in the kidneys, and deſcends by the ureter into the bladder
785. That the urine cannot deſcend by other paſſages
786. The ſituation of the urinary bladder

787. The figure and magnitude of the bladder
788. The firſt cellular coat of the bladder
Its longitudinal muſcular fibres
789. Its other muſcular fibres
790. The contractile power of the bladder
791. The ſecond cellular coat of the bladder.
The nervous coat
The innermoſt coat of the bladder
The mucus of the bladder, and its ſprings
792. The veſſels and nerves of the bladder
The lymphatics
793. That the bladder tranſmits and abſorbs water through its inorganic pores
794. That the urine flows through the ureter into the bladder.
That it remains there
The cauſes retaining the urine
795. How the urine is expelled
796. That various noxious matters are thrown off by the urine
The conſequences of a retention or ſuppreſſion of urine
797. The urethra in general
798. The parts receiving and ſupporting the urethra
The various capacity and figure of the urethra
799,——802. The muſcles governing the urethra
803. That the pyramidal muſcle has no effect in drawing the bladder downward
804. The mucus of the urethra, and its various ſprings
805. The ſtone in the urinary bladder.

CHAP. XXIX. THE MALE GENITALS.

806. The reaſon of the ſituation of the genital parts
807. A conſideration of the order
The various ſituation of the teſticles
808. The ſcrotum
The dartos
809. The cellular texture of the ſcrotum
The cremaſter
810. The vaginal coat of the teſticle
The tunica albuginea
811. The figure and ſituation of the epidydimis
812. The ſpermatic artery
The abdominal ring
The paſſage of the ſpermatic cords from thence to the teſticle
The ſmall arteries to the coats of the teſticle
813. The diſtribution of the ſmall arteries through the teſticle
That the arteries have no anaſtomoſes with the ſpermatic vein
The motion and quantity of the blood in the teſticle
814. The ſpermatic vein
815. The veſſels of the external coverings of the teſticle
816. The nerves of the teſticle.
817. The lymphatic veſſels of the teſticle
818. The internal ſtructure of the teſticle
819. The ſtructure and wandering veſſel of the epidydimis
820. The motion of the ſeed
821. The vas deferens
822. The veſicula ſeminalis
823. The ſemen
824. The animalcules of the ſemen
825. How theſe come to be in the ſemen
826. Whence the ſeed comes

Of what humours it is compoſed
What is generated in the teſticles is only prolific
How long the ſemen is preſerved in the veſſels
827. That a part of the ſemen is abſorbed, and it effects
How the ſemen is retained in the veſſels
828. The quantity of ſemen
That the ſemen comes from the teſticle into the ſeminal veſſels
829. The proſtate gland
Its liquor
829. * The three dilatations of the urethra: its various direction: its coats
[*Omitted by miſtake in its proper place*]
" 829. The urethra, though in general of a cylindric figure, " is yet dilated into three " pretty large cavities. The " The firſt is in the proſtate, " about the ſeat of the *caput gallinaginis;* the other is in the bulb; and " the third in the beginning " of the glans. Its duct is " generally horizontal at " firſt; it then aſcends along the oſſa pubis; and, " laſtly, in man it is pendulous, except during the " time of venery. It is continued from the nervous " coat of the bladder, and " is covered inwardly with " a very ſmooth cuticle, " between which and the " nervous coat is interpoſed a cellular texture."
830. The cavernous bodies of the urethra
831. How it is proved that the blood is poured into this body
832. The cavernous bodies of the penis
833. The teguments of the penis
The prepuce
The odoriferous glands
The ſuſpenſory ligament
834. The uſe of the penis
835. The erection of the penis
Its exciting cauſes
836. The arteries of the genital parts
837. The veins of the ſame parts
838. The lymphatic veſſels of the penis
The nerves of the genital parts
839. The immediate cauſe of the erection of the penis
840. The expulſion of the ſemen into the urethra
841. Its expulſion from the urethra
That this action is moſt violent, and next to a convulſion.

CHAP. XXX. THE VIRGIN WOMB.

842. The ſituation of the uterus in the pelvis
How the uterus is tied to the peritoneum
The broad ligaments
843. The body, neck, and internal mouth of the uterus
844. The tubes of the uterus
845. The ovaries
846. The eggs in the ovaries
847. The round ligament of the uterus
848. The arteries of the uterus
849. Its veins
850. The internal veſſels of the uterus
851. The lymphatic veſſels of the uterus
852. The uterine nerves

853. The age at which the menſes begin to flow
854. The phenomena of the menſes
The duration of the flux
The periods at which they return
855. That the menſtrual blood flows from the veſſels of the uterus itſelf
The nature of the menſtrual blood
That the uterus being obſtructed, the blood flows out thro' the vagina, and through oother parts
856. Whether the moon ferments, or the venereal deſire, are the cauſes of the menſes
857. The female body in general
The pelvis and its veſſels, in as far as they differ from the fabric of the ſimilar parts in a man
How the paſſage of the blood through the uterus is thence affected
859. The inferior limbs, pelvis, and uterus of a female child newly born
How the ſtructure of theſe is changed in the adult
The effects of theſe changes
860. That a plethora is generated in both ſexes when the growth of the body ceaſes
That this, in males, goes off by the noſtrils
That in women it finds an eaſier paſſage by the uterine veſſels
That there are other effects of this determination of the blood
How the quantity of the menſes is increaſed or diminiſhed
861. The quantity of the blood ſent out
The remiſſion and return of the period
Why the period is commonly fixed to a month
Why the menſes ceaſe to flow altogether
Why brute animals have no menſes
Why men want them
862. Why the breaſts ſwell out at the ſame time

CHAP. XXXI. CONCEPTION.

863. The difficulty of treating this ſubject properly
The order of treating it
864. The moſt ſimple animals which have no ſexes
How they produce their young ones
865. Oviparous animals of one ſex
866, 7. Animals of two ſexes joined in one
866. What animals impregnate themſelves
867. Animals of this kind which ſtand in need of one another's aſſiſtance
868. Animals with two ſexes divided
869. Conſequences which follow from what has been ſaid concerning the origin and ſexes of animals
870. Cauſes of the deſire of venery
871. The vagina, and its ſituation
The hymen
The *carunculæ myrtiformes*
872. The ſtructure of the vagina
873. The nymphæ
The clitoris
874. The conſtrictor muſcle of the mouth of the vagina
875. Coition
What happens to women during the time of coition

876.

876. The ſprings of the mucous liquor thrown out in coition
  That the tubes in coition are erected, and moved towards the ovarium
877, 8. What changes take place in the ovarium at that time
  The *corpus luteum*
878. How it is proved that the tube preſſes out the egg, abſorbs it, and carries it towards the uterus
879. The feelings of the future mother while theſe things are performed
  How it is proved that conception takes place in the ovarium
880. Why the uterus is thought to be ſhut after conception
  Whence the complaints after conception ariſe
881. The original ſtamina of the new animal, whether they are from both parents, and the mixture of ſeeds coming from all parts of the body
882. Whether they are only from the male and ſeminal worms
883. Whether the fœtus does not proceed rather from the mother
884. Hypotheſes concerning the formation of the new animal
885. What can be more certainly known concerning this matter
886. The ſtate of the embryo before conception
  How it is changed by the male ſemen
887. Objections from moles, of no weight
888. The change of the egg when brought into the uterus
  Its inoſculation with the uterus
889. The contents of the egg at that time
  A deſcription of the fœtus during the firſt days of conception
890. The increaſe of the egg and the fœtus until the placenta is completed
  Deſcription of the completing of the placenta
891. The placenta, and its connection with the uterus
892. The chorion
893. The middle membrane
894. The amnion
895. The umbilical vein by which nouriſhment is conveyed to the fœtus
  The cord
896. The umbilical arteries
  That theſe with their veins and cellular texture form the placenta
  That the blood goes out from the placenta into the veins of the uterus
897. Whether the fœtus takes in the liquor of the amnion by the mouth, and is nouriſhed by it
  What is the ſource of this liquor
898. The excrements of the fœtus
899. Whether there is no allantois in the human race
  That they certainly have an *urachus*
  That the urine is perhaps depoſited in the cellular texture of the cord
900. That ſome compendium of the *anthropogenia*, or formation of the fœtus, is to be given
901. What parts are formed at the very firſt beginnings of the fœtus
902. The proportion of the fluid to the ſolid parts at that time
903. The nutritious juices acceding to it
  How the blood and reſt of the humours are perfected

904. How the ſolid parts in general are formed
905. That the veſſels are the oldeſt parts of the human body
How they are produced
906. What veſſels are at firſt completed and become conſpicuous in the primeval fœtus
What are as yet involved and lie hid
907. That the motion of the heart accedes to this kind of embryo
That the heart is very large at firſt in proportion to the reſt of the body
Its pulſations are moſt powerful for diſtending and lengthening the veſſels
908. What is oppoſed to this power of the heart
How the arteries are then affected
909. That the fœtus grows moſt quickly
The cauſe of this quick increaſe
910. That the embryo is formed during its growth
910, 14. By what cauſes this is chiefly produced
910. Expanſion
911. Attraction
912. Preſſure
913. The power of derivation
Of revulſion
914. The change of the humour
915. How the bone ſucceeds the cartilage and epiphyſis.
916. How a long bone is formed
917. How the flat bones are formed
918. How a bone is produced from a gluten
That this gluten is depoſited from the inmoſt ſubſtance of the bone, and not from the perioſteum
919. The perioſteum
920. The fœtus during the firſt days of pregnacy
921. The thymus
921, 24. The proper circulation of the blood in the fœtus, and the organs by which it is performed
925. Whether the fœtus breathes in the womb
Whether it does ſo in the vagina
926. The changes which happen to the uterus during the time of pregnancy
The different ſituations of the fœtus
927. The complaints attending pregnancy
The time of delivery
928. The delivery itſelf
929. The number of fœtuſes
Superfetation
930. The looſening of the placenta
Of the navel
931. The contraction of the uterus after delivery
The lochia
The ſwelling of the breaſts
944. * The milk
Sympathy betwixt the breaſts and uterus
945. The breaſts
Their veſſels
And nerves
946. The lactiferous ducts in the breaſt
The nipple and its lactiferous ducts
The circle ſurrounding the nipple
947. Suction
The *coloſtra*, or firſt milk after delivery
That milk may be produced without a child
That the breaſts, after the menſes have ceaſed, become effete
948, 52. The changes which happen to the child after birth
948. Reſpiration
The deflexion of the courſe of

the

the blood from the *ductus arterioſus*
949. The ſhutting up of the *foramen ovale*
950. The ſhutting up of the umbilical vein and *ductus venoſus*
951. The contraction of the umbilical vein, and abolition of the urachus
952. Other changes.

Chap. XXXII. NUTRITION, GROWTH, LIFE, and DEATH.

953. That a child's growth is ſlower as it advances in age
Why the growth is continually leſſened
954. That the heart grows leſs than any other part of the body
And becomes leſs irritable
955. The end of the increaſe of the body
956. When this ſtate is ſaid to be preſent
957. How it is proved that all parts, even the moſt ſolid, are continual yconſuming and changing
958. The cauſe of the deſtruction of the ſolid parts
659. How this waſte of parts is repaired
960. How the waſte of the cellular ſubſtance and moſt organic parts is repaired
961. How the free extremities of the parts are repaired
962. Fatneſs
963. The beginnings of decay
964. The progreſs of decay
965. The dimunition of the vis inſita and nervous power
966, 8. The change of the humours
966. The decreaſe of the humours
967. The corruption of the humours
968. The increaſe of the quantity of earth in the humours
969. Old age
970. Decrepit old age
971. Longevity
972. Natural death from old age
973. The ſigns of death
974. That the carcaſe is delivered to corruption
That the ſoul remains after death, and goes to that place where God commands it.

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